**PHYS 373, Intermediate Laboratory—Nucleons: Fall 2009**

*Syllabus, September 8, 2009*


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| Instructor: | Dr. Paul M. King | Prerequisites: | PHYS 254 or PHYS 352 |
| Office: | 207 Edwards | Call Number: | 07889 |
| Phone: | (740) 593 1974 | Credit Hours: | 2 credits |
| Email: | kingp1@ohio.edu | Class Times: | Tu. & Th., 2:10 - 4:00PM |
| Office Hours: | Wednesday, 10:00 - 11:00 or by appointment | Class Location: | Edwards, rooms 208 and 101 |


# Overview:

As this will be a course on laboratory techniques, most of our time will be spent in the laboratory. However, a portion of our time each week will be spent in a seminar, to discuss general aspects of nuclear physics experiments, instrumentation, and analysis. Active participation in both laboratory and seminar components is expected from all students.

Students will be expected to complete three experiments over the course, working in small groups. Each experiment is expected to require about two weeks for proper data collection and analysis. The three experiments which I expect we will be performing will be:
1. Measurement of Rutherford scattering using the OU accelerator
2. Radioactive decay and natural abundances of uranium isotopes
3. $\alpha$ spectroscopy with silicon detectors

Depending upon the number of students, other experiments may be added, but each student will only be expected to complete a total of three projects.

Each student must keep a laboratory notebook detailing the planning for each experiment, the experimental setup and observations, and the data analysis. The notebook should include enough detail so that the student could reproduce their experiment months later, and enough detail for the instructor to understand the methods and findings of each student. The notebooks will be reviewed weekly.

Each student will submit a technical report for each of the three experiments. Although students will work in small groups to collect the data, the technical reports must be written by each individual student.

# Text:

No text is formally required for this course. Readings, equipment manuals, and references to the literature will be provided for each of the experiments. Several general references are included at the end of this document.

# Attendance Policy:

Attendance during scheduled laboratory and class times is critical in completing the required work. Students should arrive punctually for all class meetings. If you will need to miss a class meeting for reasons other than illness, please contact the instructor before the class meeting. Tardiness or leaving class early will reduce

In light of concerns related to the H1N1 influenza, I have been advised by the university to offer the following guidance:

> During the upcoming academic year, the CDC is advising universities to instruct students not to attend class if they experience symptoms such as fever, a cough, sore throat, body aches, headache, chills or fatigue. They will be encouraged instead to limit contact with others.

If you have or think you have the flu, stay home. If your symptoms persist, contact Health Services. Contact the instructor by phone or email as soon as you are able to do so, to determine how best to keep up with the class. In the event of an emergency, such as a severe outbreak of influenza, the course requirements, deadlines, and grading policy are subject to changes dictated by circumstances beyond the instructor's control.

# Grading Policy:

The grading breakdown will be as follows:

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| First lab report: | 20% |
| Second lab report: | 25% |
| Third lab report (Rutherford scattering): | 25% |
| Tutorials on data analysis: | 10% |
| Class work and homework: | 20% |

There are neither a midterm nor final exam for this course.

**Data analysis tutorials:** At the beginning of the quarter, we will go through a series of in-class and homework exercises to become familiar with the steps used in data analysis.

The analysis steps and results should be detailed in the laboratory notebook, and will be evaluated from it. In addition, a summary of the results and conclusions will be written similar in form to the "results" and "discussion" sections of a laboratory report. Further details will be discussed in class.

**Laboratory Notebook:** Each student must purchase a notebook to record the results of experiments. Records of data collection and analysis work should be included in each person's notebook.

All members of the experimental group should record the measurements in their own notebook. *Students will not receive credit for their partner's notebook!*

The raw data files produced by the data acquisition systems are stored locally on each of the computers. For each data file, be sure that you note the machine, directory, and name of the file in your notebook. In addition, your record of data files should include notes about the type of data collected, and any special conditions of the measurement.

The pages should be numbered, and entries in the notebook should be made in pen. If you have computer printouts of data tables or histograms, they should be pasted or taped into the notebook in a permanent manner. The lab book is a continuing record of what you are doing in your experiment; it should be complete and up-to-date. If you make a mistake in your notebook, it should be crossed out such that what you wrote originally may still be read. You should not leave blank space between entries; I strongly encourage you to leave blank space at the beginning of the notebook to add an index, but space between entries should be minimized. As you add entries, you should date the entries; if a particular set of entries from a single session spans multiple pages, the date should be on the top of each page.

The notebook will be used along with the reports in evaluating each experiment. The notebooks (or a copy of the relevant pages) should be submitted with the second draft of the report. They will contribute 30% of the grade for each report. In addition to whether the notebook can support the data and analysis as presenting in the report, they will be evaluated on:

**Organization and Comprehensibility** Are the pages numbered and dated? Do you have a table of contents? How easy is it to follow your work?

**Completeness** Do you have enough detail to reconstruct your work? Do you describe the steps of your analysis?

**Reasonableness of data and explanations** How well are you able to evaluate the quality of your data? Can you explain your data?

**Technical Report:** Each student will prepare a technical report individually for each experiment. Although the data collection and analysis can be done as a group, the technical reports must be individual work.

An "experiment prospectus" should be turned in the first day of data collection for each experiment, in class. This will be the first draft of the "introduction" and "materials and methods" sections of the lab report. It should describe, in your own words, the goals of the experiment, the general steps required to make the measurement, and identify the types of intermediate results which may influence the progress of the measurements. A copy of the prospectus should be taped into the notebook as a guide during the data collection. The instructor will discuss the prospectus with each lab group before the start of the experiment; additions or modifications may be made at that time.

A second draft will be due one week after the completion of the data collection for the experiment. It should include all experimental details, and data taken from your laboratory notebook. It is not expected to contain the full analysis of the experiment, but should contain the raw data and estimates of the statistical and systematic errors on the data.

The third draft lab reports will be due about two weeks after the completion of the experiment; one week after the second draft is returned. This should address all of the comments on the first and second drafts. It should have complete data analysis, and it should have all of the sections described below.

The third draft will be graded. The grading criteria will be discussed before the first report is due. If desired, the student may submit a fourth draft one week after receiving the third draft, or the day reserved for the final exam (Thursday, 19 November), whichever is earlier. By turning in an improved version, the grade for the report may be raised by one full grade point.

One reference for the style and content of the laboratory reports is that used by Dr. Roche for the PHYS 373 lab:
`http://edwards1.phy.ohiou.edu/~roche/371/how_to_write_a_lab_report.pdf`
Other useful style guidelines are given in the "Physical Review Style and Notation Guide" and the "AIP Style Manual (Fourth Edition)", both of which are available online.

The report should consist of the following recognizable sections:

**Title:** The paper title, names of the primary author and secondary authors (laboratory partners), and authors' affiliation should each be centered on individual lines.

**Abstract:** A 200-300 word description of the background, motivation, methods, and results of the experiment. This is a very condensed version of the report. A draft of the abstract should be turned in a week before the report is due; I will provide you with feedback for you to revise the abstract for the final report.

**Introduction:** This section should give some motivation of the project, to inform the reader of why they ought to care about the work. If your work attempts to demonstrate some hypothesis, it should be described in this section.

**Theoretical Background:** The physics behind your experiment should be described in this section. Equations and theoretical questions pertinent to your experiment should be introduced and discussed.

**Materials and Methods:** In labeled subsections, the materials and equipment used in the experiment should be described, as well as the methods used, discussions of statistical analysis, and the sources and estimations of statistical and systematic error. Schematic diagrams of your experimental setup should be included

**Results:** Your data should be presented in this section in the form of figures or tables. Each figure or table should be described in the text of this section, in enough detail to understand its importance to the experiment or analysis. Figures and tables may appear elsewhere in the report, but in all cases they should be numbered consecutively.

**Analysis and Discussion:** This section should explain the meaning of the results. If the introduction included a statement of hypothesis, the agreement or disagreement of the work with it should be addressed.

The discussion section should end with one or two paragraphs which summarize the work and present the final conclusions; this may be done in a "Conclusions" section instead.

**References:** All quoted material and any non-obvious statements should be cited and have their source attributed in a "References" section at the end of the report.

# Academic Honesty

Academic misconduct is a serious offense against the Student Code of Conduct, and can lead to sanctions up to and including expulsion from the university. Section 3.A.1 of the OU Student Code of Conduct (http://www.ohio.edu/judiciaries/conduct_policy.cfm) defines academic misconduct as:

> Dishonesty or deception in fulfilling academic requirements. It includes, but is not limited to cheating, plagiarism, un-permitted collaboration, forged attendance (when attendance is required), fabrication (e.g., use of invented information or falsification of research or other findings), using advantages not approved by the instructor (e.g., unauthorized review of a copy of an exam ahead of time), knowingly permitting another student to plagiarize or cheat from one's work, or submitting the same assignment in different courses without consent of the instructor.

Plagiarism can be the most subtle of the offenses, and can happen inadvertently, through improper citation. Unintentional plagiarism occurs when material is copied or copied with minor changes without properly indicating it as another's work. If you are unsure whether a citation is required, you should include a citation.

A student caught in a flagrant example of academic misconduct may be given a zero on the project or the course, and the case may be referred to the University Judiciaries. The policies and procedures and sanctions which follow from a judicial referral are detailed in the Student Code of Conduct (http://www.ohio.edu/judiciaries/conduct_policy.cfm and http://www.ohio.edu/judiciaries/conduct_procedure.cfm). In addition, all cases of flagrant misconduct or suspected misconduct will be reported in writing to the Chairman of the Department of Physics and Astronomy.

# A Suggested References

## A.1 Nuclear Data

1. R.B. Firestone, V.S. Shirley, editors, *Table of Isotopes*, 8th ed. (John Wiley & Sons, New York, 1996).
2. E. Browne, R.B. Firestone, *Table of Radioactive Isotopes* (John Wiley & Sons, New York, 1986).
3. S.Y.F. Chu, L.P. Ekstrm and R.B. Firestone, "WWW Table of Radioactive Isotopes", database version 2/28/99 from URL http://nucleardata.nuclear.lu.se/nucleardata/toi/;
   Also available from URL http://ie.lbl.gov/toi/index.htm
4. National Nuclear Data Center, http://www.nndc.bnl.gov/
5. The Isotopes Project, http://isotopes.lbl.gov/

## A.2 Detectors and Electronics

1. W.R. Leo, *Techniques for Nuclear and Particle Physics Experiments: A How To Approach*, (Springer, Berlin, 1987).
2. G.F. Knoll, *Radiation Detection and Measurement*, 2nd ed. (John Wiley & Sons, New York, 1969);
   G.F. Knoll, *Radiation Detection and Measurement*, 3rd ed. (John Wiley & Sons, New York, 2000).
3. D. Green, *The Physics of Particle Detectors*, (Cambridge University Press, Cambridge, UK, 2000).

## A.3 Data Analysis & Error Analysis

1. P.R. Bevington, *Data Reduction and Error Analysis for the Physical Sciences*, (McGraw-Hill, New York, 1969);
   P.R. Bevington and D. K. Robinson, *Data Reduction and Error Analysis for the Physical Sciences*, 3rd ed. (McGraw-Hill, New York, 2002).
2. J.R. Taylor, *An Introduction to Error Analysis*, 2nd ed. (University Science Books, Sausalito, CA, 1997).
3. L. Lyons, *Statistics for Nuclear and Particle Physicists*, (Cambridge University Press, Cambridge, UK, 1986).
4. L. Kirkup, *Data Analysis with Excel®*, (Cambridge University Press, New York, 2002).
5. R. de Levie, *Advanced Excel® for scientific data analysis*, (Oxford University Press, New York, 2004).

## A.4 Citations, Writing, and Editing

1. "Physical Review Style and Notation Guide", http://authors.aps.org/STYLE/
2. "AIP Style Manual (Fourth Edition)", http://www.aip.org/pubservs/style/4thed/toc.html
3. W. Strunk Jr. and E.B. White, *The Elements of Style,* 3rd ed. (Macmillan, New York, 1979).
4. J. Gibaldi, *MLA Handbook for Writers of Research Papers,* 6th ed. (MLA, New York, 2003).
5. R.A. Day and B. Gastel, *How to Write and Publish a Scientific Paper,* 6th ed. (Greenwood Press, Westport, CT, 2006).
6. C. Lipson, *Doing Honest Work in College,* (University of Chicago Press, Chicago, IL, 2004).