Syllabus, Physics 493
Experimental Nuclear Physics, 3 credits

Designation: Satisfies the advanced lab requirement for Physics and Engineering Physics students.

Course Description: Advanced laboratory in experimental nuclear and particle physics methodology.

Prerequisite: PHYS 315, PHYS 315L.

Required Text: Experiment writeups and supplementary materials will be provided on the class web page.

Class Web Pages: A class web page is maintained at http://phi.nmsu.edu/~pvs/teaching/phys593/

Course Objectives: Students perform a series of advanced experiments in nuclear and particle physics and apply techniques of measurement, interpretation, and presentation of experimental data.

Topics Covered: Nuclear and Particle Physics.

Class Schedule: Two 150 minute classes per week.

Contribution of Course to Professional Component: This course is designed for physics and engineering physics students with interest in nuclear or particle physics and is intended to give students hands-on experience in the experimental techniques in these fields. Students perform complex experiments, perform extensive error analysis, and present their results in written and oral reports. The course provides three credits of undergraduate physics.

Relationship of Course to Program Outcomes: This course teaches students to:

- Design and conduct experiments, as well as analyze and interpret data
- Function on multidisciplinary teams
- Communicate effectively
- Use techniques, skills and modern tools necessary for physics research

Prepared by: Dr. Vassili Papavassiliou, Fall 2017
Course Information
Physics 493–01 (Fall 2017)

Instructor: Vassili Papavassiliou

Office: Gardiner Hall 355

Office hours: MW 1:00-2:00

Phone: (575) 646-1310

Email: pvs@nmsu.edu

Course Web Page: All the course materials will be available on the web page http://phi.nmsu.edu/~pvs/teaching/phys593/

Meetings: MW 2:30–5:00 GN 218A.

Textbook: None; handouts will be provided and reference material will be made available in the labs, GN 364 and GN 65. Links to additional resources can be found on the class web page.

Material Covered: A selection of standard experiments in nuclear and particle physics, introduction to the theory of probability and statistics, principles of measurement theory and error analysis, laboratory safety, principles and operation of scientific instrumentation, scientific writing, oral presentation of scientific results.

Idea of the Course: The purpose of the Physics laboratory is three-fold:

1. To develop advanced techniques of measurement, statistical analysis, interpretation, and presentation of experimental data
2. To practice experimental design
3. To illustrate the physical principles discussed in the lecture courses

In this course, you should obtain and sharpen skills useful to a researcher in science, namely: experimental design; accurate measurement techniques; recording and organization of data; statistical analysis of data, including error propagation and use of fitting techniques; interpretation of results; presentation of results to an informed reader; and oral presentation of scientific results. In particular, you will become knowledgeable in experimental equipment and techniques relevant in particle and nuclear physics which also have applications in medical physics and materials science and engineering.

Schedule: See the Web page for tentative schedule.

Attendance: All students are required to be involved in all stages of each experiment and therefore attendance at each lab session is required unless prior arrangement is made with the instructor. Participation of each student is evaluated and unexcused absence adversely affects the student’s participation score. Repeated absences will result in a student’s not receiving credit for the relevant part.
Course Grading: The final grade will be determined by the written reports (60%), the oral exam (20%), and the lab skills score (20%). Fractional grading will be used. There is no fixed grading scale. Notice: All written reports must be turned in for a student to receive a passing grade. Please consult the online catalog for information regarding university policy on incomplete (I) grades.

Laboratory Classes: In the laboratory, students will work in teams of up to four persons which are generally fixed for the semester. The experiments are performed in class. A record of the data taking and data quality checks must be kept and every member of the team must have a copy. Each student must keep a logbook where technical details of the work and all measurements must be recorded. This logbook must be made available to the instructor upon request. Check the quality of the data by graphing your results and performing the important calculations on the spot during the data taking. If things don’t look right ask your instructor for help before leaving the class. The final data analysis can be done in class or outside class. Students are encouraged to collaborate on the data analysis.

Written Reports: Written reports will be required for each experiment, to be written individually by each student. Each report should be written as a separate paper or (preferably) submitted electronically to the instructor’s e-mail address, shown above, as a PDF document. Data should be presented as numbers as well as plotted and experimental uncertainties (“error bars”) must always be shown. The due date of each report will typically be one week after the experiment is completed. Points will be deducted for late reports. More information about the report format is given below.

Experiment Grading: The grade will be to a large extent based on the laboratory reports. Many factors enter, including: evidence of understanding of the goals of and the theory behind the experiment; demonstrated aptitude in data taking; the correctness of the analysis and statistical methods used; and the overall clarity and professional look of the write-up.

Oral Exam: Each student will be asked to demonstrate understanding of the performed experiments in an 20-minute oral exam, held during exam week. Questions will involve the theory, the experimental technique and equipment, and the analysis procedure.

Lab Skills and Participation Evaluation: Each student is expected to participate in all aspects of the experiment by contributing to the setup of the experiment, data taking, and analysis. When a student has mastered a particular aspect of the experiment, another student should take over and attempt to gain the same level of expertise until all members of the group are familiar with the process. Transfer of expertise and tutoring among students is strongly encouraged and also affects the students’ skills evaluation.

Data Analysis: Analysis of the experimental data involves the use of computers and software. Suggestions for appropriate software will be offered during the class. Students may substitute alternative software with which may be more familiar, but only if the provide equivalent functionality. As an example, a fitting program may only be used if it provides uncertainties on the fitted parameters and not only the fitted values. Students are encouraged to discuss and collaborate in the analysis but each student is responsible for understanding all aspects
of the analysis and be able to describe the procedure in the individual report and during the oral exam.

**Suggested Written Report Format:** The written report presents a description of the experiment and the relevant physics, the results, and your conclusions. Reports are written independently by each student and no copying from other students’ reports or the handouts and manuals is allowed. The report must be neatly and clearly written. The report should be a brief, but complete, description of the theory; the equipment; the measurements; the results of calculations; and the conclusions drawn. It is generally organized into several sections; some of these parts may be combined in some situations:

- Start by stating the *Purpose* of the experiment. This should include a clear statement of the hypothesis to be tested or the desired measurement.

- Describe the *Apparatus* used and define any important parameters used later in the calculations. This should include a sketch, drawing, or annotated picture of the setup on which any quantities used in calculations are defined, rather than writing a lot of description.

- Describe the experimental *Procedure* used and what measurements were performed and in what order. This can be brief and it does not need to repeat details given in any manuals.

- Present a table of *Data* obtained and the results of any calculations carried out to reduce the data.

- Discuss and evaluate the sources of random and systematic *Uncertainties* in your measurements, and propagating the errors through to the final calculations. Show a sample calculation in detail, but do not write out a series of almost identical calculations.

- State clearly all the important *Results* of the experiment, based on your measurements and calculations. Tabulate and graph results whenever possible. Include the combined random and systematic uncertainties. Present the comparison with theory or accepted results and discuss the accuracy and precision of the measurement.

- Make a short statement of the *Conclusions* which may be drawn from the results. Do your results support the hypothesis? Is your measurement in agreement, within errors, with the commonly accepted value for this quantity? If not, can you point to possible sources of systematic errors that affected the result and suggest future improvements?

- Quote any significant *References* used in the report. The preferred format is that references be cited in the relevant portion of the text, for example as a number in brackets or as a superscript, and then collected at the end of the report.

**Proper Conduct:** It is critically important that your reports do not contain text taken verbatim from other work, published or not, even if that work has been cited in the references; *this includes material that appears in the course handouts and manuals*. You should phrase everything in your own words. Copying sections may be in violation of the University’s policy on plagiarism and can result in the sanctions prescribed by the University. The following text summarizes the University’s description of plagiarism:
Plagiarism is using another person’s work without acknowledgment, making it appear to be one’s own. Intentional and unintentional instances of plagiarism are considered instances of academic misconduct and are subject to disciplinary action such as failure on the assignment, failure of the course or dismissal from the university. The NMSU Library has more information and help on how to avoid plagiarism at [http://lib.nmsu.edu/plagiarism/](http://lib.nmsu.edu/plagiarism/)

**Legal:** Please see additional pages attached to the printed syllabus.