

Physics 491 (Senior Experimental Research Project)

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Project goals, objectives, and outcomes:

A few important *goals* of the Physics Senior Experimental Research Project are for you to become adept at using equipment commonly found in modern physics laboratories, to understand and deal with sources of errors in your measurements, to gain experience in solving typical experimental problems, and to practice keeping a lab notebook and communicating experimental results.

Specific *objectives* for the project are to complete set up the apparatus proposed in a preliminary project outline, to collect and interpret data, and to communicate these results in a formal report and/or oral presentation.

Desired *outcomes* of the project are: (i) ability to design experiments and troubleshoot real-world apparatus, (ii) improved presentation skills, (iii) hands-on familiarity with modern laboratory equipment and techniques.

Project Outline:

The primary goal of the Senior Experimental Project is for you to gain experience designing and carrying out actual physics research. Thus you will be involved in the conceptual design of an experiment, purchasing of equipment/materials (if required), construction of apparatus, computer interfacing, analysis of data, and interpretation of results. The project will proceed in four main steps:

(i) Literature Search: Read, and discuss with me, several scientific journal articles related to the work that you propose to do. Write a short summary of what you consider to be interesting/important about these articles, and outline the research you propose to do. (One page report due at the start of the start of the quarter.)

(ii) Construction of apparatus/ collection of data: Please keep a detailed account of all the time you spend in the laboratory in your lab notebook. Your lab notebook should contain dates and times at which work was done, brief descriptions of procedures, diagrams of apparatus, serial and model numbers of equipment used, graphs, tables of data, calculations, notes about what you consider to be anomalous conditions in the laboratory. Think of it as a scientific journal in which you keep a daily record of *everything* that goes on in the lab. 99% of what goes into the notebook should be written *while in the laboratory*. Even if you are working with someone else on an experiment, please keep your own record of the proceedings. The notebook should be legible, but do not be overly concerned with neatness. Do not rip pages out of the notebook, or use white-out; simply cross out mistakes. (Often it is the "mistakes" that lead to significant scientific discoveries.) Make sure you number the notebook pages and provide a table of contents.

I will look through your lab notebook periodically throughout the quarter and give you feedback on how you are doing.

(iii) Formal Report and Poster: You will be required to write a 3 to 4 page formal report on your experiment. The report should be modeled after articles appearing in the *Journal of Applied Physics* (in the Physics Library). The report should include a title, abstract, brief introduction to the subject and motivation for doing the experiment, discussion of procedures and results, figures (with captions!), and a list of footnoted references.

(iv) Oral Presentation: This will be a 20 minute summary of your work delivered in a department or Junior Lab seminar. The talk should use powerpoint or equivalent presentation software.

Lab Notebook:

Please purchase a large format notebook with **numbered** pages (Ampad No. 22-156 or Roaring Spring 77155, available in the bookstore). A significant portion of your project grade will be based on what you write down in your lab notebook *while in the laboratory*. Your lab notebook should contain dates and times at which work was done, brief descriptions of procedures, diagrams and/or photos of apparatus, serial and model numbers of equipment used, graphs, tables of data, calculations, notes about what you consider to be anomalous conditions in the laboratory. Think of it as a scientific journal in which you keep a daily record of *everything* that goes on in the lab. **99% of what goes into the notebook should be written while in the laboratory.** Even if you are working with someone else on an experiment, please keep your own record of the proceedings. *Do not* simply copy your lab partners notes (you will lose marks if you do!). The notebook should be legible, but do not be overly concerned with neatness. Do not rip pages out of the notebook, or use whiteout; simply cross out mistakes. (Often it is the "mistakes" that lead to significant scientific discoveries.)

IMPORTANT: The accuracy and completeness of your lab notebook will greatly affect your ability to communicate your progress to me at our weekly meetings!

IMPORTANT: please reserve the first few pages of the notebook for a Table of Contents. Update this table of contents at the end of each lab session.

IMPORTANT: although I will not do a detailed grading of your notebook I will give you a mark for the "overall impression" that I get from you notebook. At the end of the quarter I will collect the notebooks and I'll do spot-checks for things like dates, table of contents, missing pages, relevant diagrams, sample calculations, graphs of data, etc. The following grade table will be used in assigning your notebook mark.

Dates/ times	Lab notes entered <i>during</i> lab	Overall goals (start of each new entry)	Brief Procedure descriptions	Partner name and/or other help received	Diagrams and photos of apparatus	Serial/model numbers of apparatus	<i>Labeled</i> graphs of data	<i>Labeled</i> tables of data	Mistakes <i>crossed out</i> not torn out	references	Table of contents

Error Analysis:

It is assumed that you have a strong working knowledge of the error analysis topics covered in Physics 326. Please look over the material you covered in the textbook for 326, *An Introduction to Error Analysis* by Taylor. It is expected that whenever experimental uncertainties are encountered in your senior project you record them and follow through with a rigorous treatment of propagation of errors in any calculated values.

Formal Laboratory Reports:

You will be required to write a short (roughly 3 pages) report and/or prepare a poster on your quarter's work. The report/poster is primarily an exercise in scientific writing and as such it should conform to standard journal format. The report should include a title, abstract, brief introduction to the subject and motivation for doing the experiment, discussion of procedures and results, figures (with captions!), and a list of footnoted references. See the project webpage link "[Formal Lab reports](#)" for more details. Feel free to ask me to read and comment on rough drafts of the reports. However please make sure that you do this *well in advance* of the end of the quarter.

Student Seminars:

You will give a seminar on your project (roughly 20 minutes) towards the end of the quarter. Please see me early in the quarter to schedule a specific date. The seminar should conform to the standard format used at scientific conferences. The project webpage link "[Oral presentations](#)" gives details on this format. Powerpoint (or equivalent software) must be used. The presentation should be pitched at the level of a Physics 224/225 student. Physics majors will be encouraged to attend your talk and ask questions.

Weekly Meeting

I will have a scheduled one-hour meeting with you each week of the project. Please bring your lab notebook to this meeting. I will assign a grade out of 2 to each meeting. Provided you have done significant work on the lab since the last meeting and it has been adequately recorded in your lab notebook you will get full marks (Plan for at least 4 hours of lab work per week.). Showing up for the meeting with little or nothing to show for the last week will result in a 1. Missing a meeting without contacting me beforehand to reschedule it will result in a 0.

Access to the laboratories:

A lockbox code for getting into laboratories will be given out at the beginning of the quarter. You are expected to be responsible and make sure that any equipment you use is shut down properly, the radioactive sources are put back in their storage area, and the **laboratory doors are locked** when you leave.

Laboratory rules and safety issues:

1.) Make sure that you have told at least one other person which lab room you are in and for how long you will be there. This is absolutely essential for experiments involving lasers, high voltages, gas cylinders, or procedures that require the use of a fumehood. Ideally, try to plan your work schedule so that other students are in the same or adjacent labs at the same time as you.

2.) No food in the laboratories! There are radioactive isotopes as well as residual quantities of lead and other toxic materials in the laboratories. Be sure to wash your hands after being in a lab!

3.) Do not operate radios, mp3 players etc., while experiments are going on (even with headphones)! Often the slightest of sounds in the laboratory can alert us to dangerous conditions (e.g. uninsulated high voltage terminals, leaking gas cylinders, vacuum leaks, broken cooling fans, etc.). Masking these sounds can create dangerous conditions.

4.) Adequate eye protection must be worn in all labs involving lasers. Ask the instructor if you are not sure where laser safety goggles are located. Make sure that the goggles you are using are matched to the wavelength of light in your experiment. Also please make sure that laser beams from your apparatus do not inadvertently enter the workspace of another student. (Draw the black curtains around your setup whenever possible.) Several of the experiments use infrared lasers whose beams have the added danger of being invisible.

5.) Before beginning work in the lab you are required to take a short WWU safety training course in the use of radioactive materials. This course is mandatory even if your experiment does not involve radioactive materials. Please ask the instructor to enroll you in the project at the start of the quarter.

Grades:

	Mark allotment
Literature review	10
Notebook mark	40
Weekly meetings	20
Formal report/ Poster	15
Oral presentation	15

LETTER GRADE SCALE

Percentage	90-100	85-89	80-84	77-79	73-76	70-72	67-69	63-66	60-62	57-59	53-56	<53
Grade	A	A-	B+	B	B-	C+	C	C-	D+	D	D-	F