Physics 391 Junior Physics Lab, Winter Quarter 2022

Weekly student seminars: Wed 4-5 pm in CF314 (four or five 12-minute seminars per week)

Meetings with instructor: Each lab group has a minimum of a one-hour long meeting with the instructor each week (the group meeting time is scheduled during the first week of class). Additional time may be scheduled if necessary.

Lab location: Various rooms in the basement of the Communications Facility (CF10, 11, 12, 15, 16, 21)

Instructors:

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Prerequisites:

Physics 326, Tools and Data Analysis
Physics 322, Fundamentals of Electronics
Physics 225, Modern Physics II

Course goals, objectives, and outcomes:

A few important *goals* of the Junior lab course are for you to become adept at using equipment commonly found in modern physics laboratories, to be aware of sources of error in your measurements and to develop strategies to minimize these as much as possible, to gain experience in solving typical experimental problems, and to practice keeping a lab notebook and communicating experimental results.

Specific *objectives* for the course are to complete 4 experiments from the 40 or so choices. See the list of experiments webpage, on Canvas, for links to summaries and guide sheets for the available experiments.

An important component of Physics 391 is the weekly seminar where all students will be required to give an oral presentation on one of their experiments. This seminar, together with hands-on laboratory work, contributes to several desired course *outcomes*: (i) improved presentation skills, (ii) ability to design experiments and troubleshoot real-world apparatus, (iii) familiarity with a broad range of experiments that form the foundation upon which modern physics is built.

Reference Materials:

Brief introductions to the experiments, a list of references, and in some cases, detailed guide sheets are posted on the course's Canvas site. This page also contains useful links including the course syllabus, guidelines for formal reports and presentations, safety rules, detailed schedules, and grades.

An extremely useful text for the course is *Experiments in Modern Physics (2nd ed.)* by Melissinos and Napolitano. Both the first and second editions of the text are available in the WWU library. The first edition is very useful for a few experiments not covered by the 2nd edition. You will also probably need to make regular use of texts used by prerequisite courses including an error analysis text such as *An Introduction to Error Analysis* by Taylor.

Please make sure you have access to data analysis software such as *Kaleidagraph* or *Origin.* (Installed on most laboratory computers and in all computers in CF312). You will be using this software extensively for plotting, curve fitting, and other forms of data analysis. *Excel* is also useful for some forms of data analysis. However, by itself, *Excel* is *not* sufficient for Junior Lab. *Kaleidagraph* and a number of other applications used in the Junior Lab are installed on all lab computers. You can access these computers in-person or remotely via VPN on your own computer. Please make sure to install VPN and Remote Desktop and get them working on your computer in the first week of class. Instructions on how to do this are given on the 391 Canvas site. Please contact me or Geordon Brewer (brewerg@wwu.edu) if you have any trouble with the installation.

Many other universities have similar Junior Lab courses and you are encouraged you to consult their web pages for additional information and ideas. For example, see:

MIT	http://web.mit.edu/8.13/www/index.shtml
CalTech	http://pmaweb.caltech.edu/~ph77/
University of Toronto	http://www.physics.utoronto.ca/~phy326/explist.htm
Berkeley	http://experimentationlab.berkeley.edu/
AAPT webpage	http://www.compadre.org/advlabs/

Important Dates

Week	
1 (Jan 4-7)	Go over syllabus, scheduling, watch intro videos, other course startup tasks (See Canvas site for details.) start on 1st experiment if desired
2 (Jan 10-14)	Quiz 1 1st experiment
3 (Jan 17-21)	Quiz 2 1st experiment
4 (Jan 24-28)	2nd experiment
5 (Jan 30-Feb 4)	2nd experiment
6 (Feb 7-11)	**Test 1 Mon, Feb 7, 4pm** 3rd experiment
7 (Feb 14-18)	3rd experiment
8 (Feb 21-25)	4th experiment
9 (Feb 28-Mar 4)	4th experiment
10 (Mar 7-11)	**Test 2 Mon, Mar 8, 4pm** **Formal report due Fri Mar 11, 5pm** **Hand in Lab Notebook by Fri Mar 11, 5pm**
Finals Week	**Course exam: Monday Mar 14, 1:00-3:00pm in CF310**

Lab Notebook:

Please purchase a large format notebook with **numbered** pages (Roaring Spring calculation book or equivalent, available in the bookstore or Amazon). Further details about the type of notebook and what should go in it are given on the Canvas Home page. A significant portion of your course mark 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**. Most 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: You will be allowed access to your lab notebook during the two midterm tests. Thus the accuracy and completeness of your lab notebook will greatly affect your ability to do well on these tests!

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: Please bring your lab notebook to our weekly meetings. The instructor will look through it at each meeting to review what you have done in the lab and also give you suggestions on possible improvements that could be made. At the end of the quarter we will collect the notebooks and we'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 (1 mark deducted in each category that is not satisfactory. Total laboratory notebook mark is out of 4experiments x 12 =48 points)

Expt	Dates/ times	• Lab notes entered *during* lab. • Mistakes *crossed out* not torn out. • No loose photocopies/ printed sheets	Start of a new Lab: what is this lab about? (half page) Start of each new day: Overall goals for today	Brief Procedure descriptions notes about relevant lab conditions	Partner name and/or other help received	Diagrams and photos of apparatus Printouts of computer programs used	Serial/model numbers of apparatus	*Labeled* graphs of data useful scope photos (give axis values)	*Labeled* tables of data.	Sample calcs of values and error analysis	Final conclusions, error estimates, theory comparisons, references	Table of contents

Error Analysis:

The junior lab will require you to 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. The two midterm tests and the final exam for 391 may include general error analysis problems or problems that relate to the specific experiments that you have done.

Quizzes:

There will be two 10 question multiple-choice quizzes administered via Canvas. You can use whatever resources you wish to do them. Quizzes will take about 10 minutes to do.
Quiz 1 possible topics: the syllabus, basic questions relating to the introductory videos and lab safety.
Quiz 2 possible topics: basic error analysis questions covered in the Week 2 error analysis review lecture.

Tests:

There will be two midterm tests during the quarter, one which covers the first two experiments that you have done, and one which covers the last two. The only aids allowed in these tests will be your lab notebook, a calculator, and the error analysis text that you used in Physics 326 (Taylor). The tests may include conceptual questions about the physics behind the experiment (e.g. What is the photoelectric effect?) as well as specific questions about the apparatus that you used. (e.g. What was the gain used on your linear amplifier? What model of oscilloscope did you use? What range setting did you use in voltmeter measurements?) In addition, the tests may contain error analysis questions that are related to the two experiments that you are being tested on.

Formal Laboratory Reports:

You will be required to write one 3-page report on an experiment that you have done in the course. Lab partners must write on different experiments. The report 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 link on the Canvas page entitled formal lab reports for more details on the report format. Feel free to ask the instructor to read and comment on rough drafts of the reports. However please make sure that you do this *well in advance* of the report deadline.

Student Seminars on Mondays:

You will give a seminar (10 minutes maximum plus 2 minutes for questions) on one of your experiments during the quarter. You may either present your own data or, if need be, summarize the results of another experimenter (journal data, textbook data, etc.). The point of this exercise is to give you practice in giving a scientific talk. As such the seminar should conform to the standard format used at scientific conferences. The link on Canvas entitled seminar presentations gives details on this format.

In order to ensure lots of variety in the seminars it is required that every student talk about different experiments. Please select a topic, and schedule your seminar date with the instructors as soon as possible. Topics will be assigned on a first-come, first-served basis.

Powerpoint (or equivalent software) must be used. The presentation should be pitched at the level of a Physics 224/225 student. Students are required to attend all the seminars, and encouraged to take notes, and ask

questions. Active participation in the seminar series will help you prepare for the final exam. **Please drop a copy of your presentation onto the Canvas page entitled student seminar slides.**

Final Exam

The final exam will be primarily multiple choice. The topics covered will be some subset of the experiments covered by the Monday student seminars. Which subset of experiments to be covered will be announced in the week before the exam. Many of the questions on the exam will pertain to experiments that you have not personally done, but only heard about in your courses and/or student seminars. The exam may also include error analysis questions of a general nature. The only aids allowed in the final exam will be a calculator and the error analysis text that you used in Physics 326 (Taylor).

Pre/Post course survey

As part of our effort to continually improve our labs we will be administering a web-based pre/post course survey designed by the University of Colorado. As an incentive we are allotting 5% of your course grade to participation in this survey. There are no right or wrong answers to the questions in this survey. You will receive the full 5% as long as you take the pre and post course surveys. A link to the survey is posted on the Canvas site under Course Schedule Week by Week. Look under week 1. This link will only remain active for the first week of the course so please take the survey as soon as possible. A link for the post-course survey will similarly be posted near the end of the course.

Weekly Meeting

The instructor will have a scheduled one-hour meeting with each lab group each week of the course. Please bring your lab notebooks to this meeting. The instructor 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 the instructor beforehand to reschedule it will result in a 0.

Work outside of the scheduled laboratory hours:

A lockbox code for getting into laboratories will be given out at the beginning of the quarter. As mentioned in the Safety section below, you are required to use the "buddy system" and follow all safety precautions. Please double check that the **laboratory doors are locked** when you leave.

Laboratory rules and safety issues:

1.) Use the "buddy system": whenever working in the lab make sure there is at least one other person in the room with you. This is especially important if you are working with experiments involving lasers, high voltages, high pressure gases, or procedures that require the use of a fumehood. Even if your experiment does not involve any of the above, the room you are in may still have safety precautions that need to be followed. Ask the instructor about these. Make sure that whenever you are working in the lab someone outside the lab knows where you are and for how long.

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. Be sure to talk about safety procedures with the instructor before beginning any lab with such lasers.

5.) A few of the experiments in Junior lab require you to use toxic chemicals (eg. photographic processing chemicals, precursors for making high temperature superconductors, lead bricks for radioactive shielding). Make sure you read the Materials Safety Data Sheets (MSDS) or the newer format Saftey Data Sheets (SDS) for chemicals that you are using in Junior Lab experiments and take required precautions. In most cases, links to relevant MSDS or SDS sheets are given on the Experiment's Canvas web page. If no link is provided, please find the MSDS or SDS sheet on the web and read it.

6.) **Compressed Gases:** If the head of a compressed gas cylinder is knocked off in an accident, the cylinder becomes a torpedo that can smash through concrete walls! **Under no circumstances should you try to move a compressed gas cylinder.** Ask Physics Department staff to do it for you if necessary. All cylinders in the building must be tethered to a fixed point (wall or heavy table) so it is not possible for the cylinder to be accidentally knocked over. **If you ever see a cylinder that is not tethered, please report it immediately to an instructor or staff member.**

Please see additional references regarding Safety in the Junior Lab on the Canvas site

Covid-19, Accommodations, and General WWU policies

Covid-19 has taken all of us into new territory! Please let us know if you have circumstances that require accommodations and we will our best to help. If you have ideas on how to make the course run more smoothly please feel free to offer suggestions.

In general, missed tests, laboratories, and other components of Physics 391 will be assigned a mark of zero unless the absence is excused in accordance with general WWU policies. Please read the document https://syllabi.wwu.edu/ for information on covid-19 related accommodations as well as complete information on general WWU topics such as Academic Honesty, Accommodations, Ethical Computing Resources Conduct, Equal Opportunity, Finals, and the Student Conduct Code.

Grades:

Tests (2 midterms, each covering two experiments)	30% (7.5% each experiment)
Final exam	15%
Pre/post survey participation	5%
Weekly meetings	5%
Quizzes	5%
Formal written report	10%
Seminar	10%
Lab notebook	20%

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