# West Chester University

# Department of Physics

# Physics 320 – Intermediate Lab II

**Meeting Times:** MWF 3:00 - 5:45 pm

**Meeting Place:** Merion Science Center 109

**Instructor:** Jeffrey J. Sudol (Dr. Jeff)

**Office:** Merion Science Center 130

**Office Phone:** 610-436-2572

**Office email:** jsudol@wcupa.edu

**Office Hours:** MF 1-3, W1-2

## Course Description

During the Physics 310-320 sequence, you will conduct several of the classic experiments from the 19th and 20th centuries designed to measure the fundamental constants of nature, such as the Universal Gravitational Constant, the speed of light, the charge of the electron, and Planck's constant. These experiments lie at the heart of modern physics, and the structure of the Universe depends critically on the values of these constants.

## Required Course Materials

- ✓ *An Introduction to Error Analysis*, 2nd edition, Taylor.
- ✓ A laboratory notebook.
- ✓ A scientific calculator.

## Attendance Policy

Attendance is required.

## Website

This course has a D2L website associated with it. I will post all course documents and announcements on the D2L website. Please check D2L frequently.

## Course Goals

Physics 320 is an approved Writing Emphasis course in the WCU General Education program. The writing sessions and draft review meetings that take place during the semester, as well as the feedback that I give you on your papers, and the experimental work that you do throughout the semester, are all designed to help you meet the following General Education goals: (goal #1) students will be able to communicate effectively, (goal #2) students will be able to employ quantitative concepts and mathematical methods, and (goal #3) students will be able to think critically and analytically.

In more discipline specific terms, this course is designed to meet the following goals.

1. The student will become adept at using a wide range of experimental tools and measurement techniques common to the modern physics laboratory.

2. The student will become adept at using a wide range of statistical tools to estimate and calculate uncertainties.

3. The student will advance his or her ability to communicate the design of an experiment and the results of that experiment to an audience of physicists in writing through formal research style papers and in person through research talks.

## The Experiments

During the semester, you must conduct four experiments that you have not conducted previously and document those experiments in a laboratory notebook. At least two of the experiments must come from the PHY 320 list below. You must write and submit research papers for three of the experiments, and prepare a research presentation for the fourth. The experiment on which you present must also come from the PHY 320 list below.

PHY 310

The Universal Gravitational Constant (The Cavendish Experiment)
The Speed of Light
The Charge-to-Mass Ratio of the Electron
The Fundamental Unit of Electric Charge (The Millikan Oil Drop Experiment)
The Magnetic Permeability of Free Space (The Current Balance)
Planck's Constant (The Photoelectric Effect)
The Half-life of a Barium-137m[1]
The Wavelength of Helium-Neon Laser Light (Michelson Interferometry)

[1]This experiment requires training in the safe handling of radioactive materials.

PHY 320

Electron Spin Resonance
Avagadro's Number (Bragg Diffraction)
The Hall Effect in Silver
The Zeeman Effect (Fabry-Perot Spectroscopy)
The Quantization of Electron Energy Levels (The Franck-Hertz Experiment)
Nuclear Spectroscopy of Materials[1]
The Index of Refraction of Air (Michelson Interferometry)[2]
The Sodium Doublet[3]
The Mass of the Neutron[3]

[1]This experiment requires training in the safe handling of radioactive materials.
[2]This experiment requires an excel spreadsheet maintained by Dr. Sudol.
[3]This experiment is "undocumented." Ask Dr. Sudol to define the objective of the experiment.

## The Laboratory Notebook

You will maintain a laboratory notebook during this course as you did in PHY 170/180/310. Your laboratory notebook will serve as the foundation on which your research papers and presentation are built. Your laboratory notebook must be available for review at all times to substantiate any of the claims that you make in your research papers or presentation.

## Laboratory Practices

As in PHY 310, you are on your own recognizance to conduct experiments in the laboratory space dedicated to this course (MER 114 and MER 116). In other words, you set your own schedule, except with regard to the deadlines for papers and the presentation.

You must develop your own procedures for conducting each experiment and analyzing the data.

You must make arrangements with the other students in the class so that no conflicts occur with regard to the use of the equipment or the laboratory space. You must keep the laboratory space in good working order at all times.

You must avoid creating safety hazards. If, at any time, I find that an apparatus presents a safety hazard, I will lock everyone out of the laboratory until the person who created the hazard removes it.

This arrangement is designed to encourage you to engage in professional conduct. In general, in the sciences, laboratory facilities and laboratory equipment are shared due to their high cost. Consequently, coordination and cooperation are critical to everyone's success.

In the interest of lab safety, you must work with at least one other student on all experiments. In the interest of equal participation, however, you may not work in groups of more than three students.

## Caring for Equipment

The equipment that you will use to conduct experiments during this course is quite expensive. In total, the equipment costs in excess of $150,000. Individual items can be quite expensive, too. For example, the Fabry-Perot etalon costs $3,500, and the x-ray diffractometer costs $22,000.

Caring for the equipment requires no special training. All of the manuals for the equipment in the lab are available on D2L. I expect you to read the manual for each piece of equipment from cover to cover before using the equipment.

To hold you accountable for taking good care of the equipment, the following policies are in effect.

1. All of the equipment cabinets in the labs are locked. A complete inventory of the equipment is available on D2L. You will automatically receive a failing grade for the course if I find that you have tampered with any of the locks.

2. Dr. Naveen Jha and I will be available three times each week to release equipment and take equipment in return. (TBD)

3. You must submit an "Equipment Request" to either me or Dr. Jha (njha@wcupa.edu) on paper one day in advance of the date you want to take possession of equipment. The Equipment Request form is available on D2L. If someone else has submitted a request for the same equipment ahead of you, or if someone else is in possession of the equipment, we will not be able to release the equipment to you. You must communicate your equipment needs to your fellow students so that no conflicts occur (see **Laboratory Practices** above).

4. You may not take possession of more equipment than is required to run one experiment at a time.

5. You will automatically receive a failing grade for the course if I find that you are using equipment that (1) has not been released to you, (2) is not part of the equipment inventory, or (3) has not been sanctioned for use in the lab by me.

6. You have two hours after receiving any piece of equipment to check that equipment for damage and report any problems. (See item #8 below.)

7. Penalties for damaged equipment are assessed as follows.

   Whenever a piece of equipment is damaged, I will charge all students in the course a "$100 penalty." (I am not actually charging you $100. You do not have to pay to replace broken equipment. This is an "accounting mechanism" for grade penalties, which is described further below.) This charge takes into account the possibility that prior students have abused the equipment in some way, making it susceptible to failure.

   I will charge the individual who damaged the equipment the full cost to repair or replace the equipment. If an entire group is responsible for the damage, I will divide the cost to repair or replace the equipment amongst the group.

   The group in possession of the damaged equipment must complete a repair order or a replacement part order to my satisfaction before the group may take possession of any additional equipment. (Equipment Repair and Equipment Replacement forms are available on D2L.)

8. If you receive equipment that is damaged, Dr. Jha and I will begin an investigation into the cause of that damage and assess penalties as we see fit. We are the sole judges in these matters, and our decisions are final.

   Penalties are doubled for equipment that is returned damaged without notification.

9. Penalties for damaged equipment translate into grade penalties. After assigning a grade to a paper or presentation, I will deduct a partial letter grade for each increment of $500 in penalties accrued since the previous paper or presentation. Any remainder carries over to the next graded item. For example, if you receive a B+ on a paper, and you have accrued $800 in penalties, your grade drops to a B, and the remainder, $300, carries over to the next graded item.

## Research Papers

The research papers that you submit must conform to the standards of research publications in physics and astronomy. The *American Institute of Physics Style Manual* will serve as our primary source for these standards. If the AIP manual does not address a particular issue, consult the instructions for authors for *The Astrophysical Journal*, found at the following URL:

http://aas.org/authors/manuscript-preparation-aj-apj-author-instructions.

Automatic failure will result for papers that have the following obvious faults (this is equivalent to a paper being rejected for publication without review).

- More than three (unique) spelling errors.
- More than two incomplete sentences or sentence fragments.
- Failure to define a variable for a physical quantity. (Mathematical constants, such as $\pi$, are exempt.)
- Variable confusion. (For example, using the variable $F$ to represent the force of gravity on an oil droplet and the same variable, $F$, to represent the electrostatic force on the oil droplet. Use subscripts to distinguish variables from one another; for example, $F_g$ and $F_e$. Similarly, using $k$ to represent a spring constant, then, later, $\kappa$ to represent the same spring constant.)
- Failure to report a numerical value for all variables critical to calculating the final result.
- Failure to follow convention for reporting numerical values.
- Content that appears after the reference section.
- Text in Tables and Figures that is not legible.
- Tables or Figures that violate the margins.
- A Table or Figure caption that does not appear on the same page as the Table or Figure.
- Failure to post any authoritative references.

*Draft Review*

I will meet with each of you, individually, for 30 minutes to comment on each of your papers before you submit a final draft. Please bring two copies of your paper to these draft review meetings, one for me to read and one for you on which to take notes.

Unfortunately, the phrase "draft review" is a bit misleading. Don't be misled. During draft review you must submit what you intend to be the final draft of the paper. Failure to present a complete draft will result in the loss of an entire letter grade on the final draft of the paper.

*Final Draft*

The final draft of each paper is due one week after we meet for draft review. I will dedicate one hour to writing comments on your final draft to help you improve your writing. As this is the second course in the two course sequence, all papers and presentations are graded on the same expectations, as described in PHY 310.

**Research Presentations**

Toward the end of the semester, you will give a talk describing one of your experiments and its result to an audience of your peers and professional scientists, notably, the faculty in the Department of Physics. The experiment on which you give the talk must be different from one of the four for which you wrote a paper and must come from the list of PHY 320 experiments. Your talk is limited to 15 minutes in a 20 minute time slot, leaving 5 minutes for questions. Members of the audience may interrupt you at any time during the presentation to ask questions. The faculty and I will provide written feedback on your presentation afterwards.

No more than three students may present on a particular experiment. You must inform me of the experiment on which you will present and select a date and time to present no later than March 15.

**Assessment**

Your "grade" in this course will be based on your performance in the following categories of assessment with the following weights.

(3) Research Papers ..... 25%, 25%, 25%
(1) Research Presentation ..... 25%

I will assign each paper and presentation a letter grade of A, B, C, D, or F, based on my professional judgment.

I reserve the right to introduce different forms of assessment as needed and to alter the weight of each of the categories of assessment in the event of some unforeseen circumstance.

Note that I am not the sole judge of your performance. During the research presentations, other faculty in the department will evaluate your work and submit their evaluations to me for consideration.

**Email Policy**

Per the Undergraduate Catalog, you are required to activate and maintain the email account created for you by West Chester University. I will not use any other email account to communicate with you.

**Disability Statement**

If you require special accommodations because of a disability, please meet with me as soon as possible to discuss your needs. Supporting documentation from the Office of Services for Students with Disabilities (OSSD) is required. For more information regarding this policy, click here: Undergraduate Catalog: Services for Students with Disabilities.

**Policy Regarding Grade Assignments**

Grade assignments are final and cannot be changed once submitted at the end of the semester, unless a clerical or computational error is discovered. "No Grade" assignments are made only under extraordinary circumstances. Credit by Examination is not available for this course. For more information, click here: Undergraduate Catalog: Grade Changes.

**Academic Integrity Statement**

If you commit a violation of academic integrity, you will receive zero credit for the entire course. This is not negotiable. For more information regarding violations of academic integrity, click here: Undergraduate Catalog: Academic Integrity Policy.

**Student Code of Conduct**

I will dismiss students from class for any violation of the Student Code of Conduct and initiate the disciplinary action appropriate to the violation. For more information regarding violations of the student code of conduct, click here: Student Code of Conduct, and here: Undergraduate Catalog: Disruptive Classroom Behavior.

**University Sanctioned Events**

If you will be participating in a University sanctioned event that occurs at the same time as an exam (the exam dates on the **Course Schedule** will not change), you must notify me one week prior to the exam. Documentation supporting your participation in this event is required. We will then make arrangements for you to take the exam at a later date or at the scheduled exam time through a proctor.For more information on University Sanctioned Events, click here: Undergraduate Catalog: University Sanctioned Events.

**Intellectual Property Statement**

All of the course materials, including the PowerPoint lectures and exams, are the intellectual property of the instructor or another author. Your use of these materials is restricted to your own studies for the duration of this course. It is a violation of Federal Law for you to distribute copies of these materials to anyone in any format at any time.

**Electronic Equipment in the Classroom (Unplug)**

Except for calculators, I do not permit the use of cell phones, cameras, voice recorders, computers, or similar electronic equipment in the classroom unless you need to use such a device to accommodate for a disability, in which case you should schedule a meeting with me to discuss the proper use of the device and the data obtained with that device as soon as possible. The spirit of the rule is that the classroom should be an electronic free zone where we tune out the distractions of the world and focus on learning physics. The classroom is a place of dialogue, and the electronic gadgets of our modern culture are not necessary for that dialogue to take place.

**Course Schedule**

Note: We will set meeting times for draft review during the first class session. Draft Review is not available for Paper #3.

| Date | Lecture Activities |
|---|---|
| Jan. 21 | Laboratory Practices and Data Analysis Session #1: Resolution |
| Jan. 26-30 | - |
| Feb. 02-06 | - |
| Feb. 09-13 | Draft Review |
| Feb. 16-20 | Paper #1 Due |
| Feb. 23-27 | - |
| Mar. 02-06 | Draft Review |
| Mar. 09-13 | *Spring Break* |
| Mar. 16-20 | Paper #2 Due |
| Mar. 23-27 | - |
| Mar. 30 - Apr. 03 | - |
| Apr. 08 | Student Presentations |
| Apr. 15 | Student Presentations |
| Apr. 22 | Student Presentations |
| Apr. 27 - May 01 | - |
| May 04 | Paper #3 Due |