West Chester University, Department of Physics

PHY320: Intermediate Physics Lab II (FALL 2020)

Prof. Brandon Mitchell Room SSS-402A e-mail: bmitchell@wcupa.edu

Lecture: Tuesdays from 3 – 3:50 pm on ZOOM

Office Hours: My office hours for Fall 2020 are:

M: 1:30 – 2:30 **W: 1:30 – 3:30** **F: 1:30 – 2:30**

Please sign up for office hours at: https://calendly.com/prof-mitchell

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Required Textbook:

An Introduction to Error Analysis, 2nd edition, Taylor

Course Web Page on D2L: Due to COVID-19, this course will be performed in a Hybrid Manner. The D2L page will be a critical resource for experiment videos, documents and for submission assignments.

ZOOM: All lectures will be given synchronously via ZOOM. You are expected to have a web camera and participate in these lectures.

Content: During the PHY 310 sequence, you conducted several of the classic experiments from the 19th and 20th centuries designed to measure a fundamental constant of nature, such as the universal gravitational constant (G), the speed of light (c), the charge of the electron (e), and Planck's constant (h). Those experiments lie at the heart of modern physics, and the structure of the Universe depends critically on the values of these constants, and blah, blah, blah…. That's great and all, but it is time to advance to world of "effects. In PHY320, you will be conducting experiments, where the outcome is an effect described by a theory with a parameter that changes between studied systems such as the g-factor, lattice spacing or the Verdet constant. You will gain an understanding of how the properties of materials or systems are determined through their relationship with other measurable quantities through a theory or model. You will be OK with not truly knowing or fully understanding what you are looking for as you are conducting an experiment. In fact, some experiments may require you to learn additional material not covered until PHY420 (Quantum Mechanics I) or Solid-State Physics (PHY480 – Sometimes), such as the Zeeman effect or X-Ray Diffraction analysis. This happens all the time, I am probably reading a bunch of papers right now to understand a topic that I am not familiar in order to write a grant to perform an experiment tangentially related to it. That's physics!

Expectations: Physics 320 is an approved Writing Emphasis course in the WCU General Education program. The writing sessions, laboratory practices and data analysis sessions, and draft review meetings that take place during the semester, as well as the feedback that the faculty give you on your papers and presentations, 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 proficient at using a wide range of experimental tools and measurement techniques common to the modern physics research laboratory.
2. The student will become proficient at estimating and calculating 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.

PHY320 – Exploration of Physical "Effects": PHY320 will build upon PHY310 and reinforce the ideas how to conduct an experiment, keep track of uncertainty, and come to a conclusion based upon the analysis of the data. In this case, you will be conducting an experiment where the outcome is an effect described by a theory with a parameter that changes between studied systems such as the g-factor, lattice spacing or the Verdet constant.

During the semester, you will complete the analysis of **three** experiments from the list of PHY 320 experiments below. For the 1st experiment, choose one of the following:

1. Electron Spin Resonance
2. The Zeeman Effect
3. X-Ray Diffraction Analysis of NaCl

For the 2nd and 3rd experiment choose any of the seven experiments:

1. The Hall Effect
2. The Faraday Effect
3. Sodium Doublet
4. Electron Spin Resonance
5. The Zeeman Effect
6. Nuclear Magnetic Resonance
7. X-Ray Diffraction Analysis of NaCl

You will write a one-page conference abstract for the first two experiments. You will also prepare a research presentation and full "conference proceeding" for the second experiment. Lastly, you will write a full-research paper for the third experiment.

The Laboratory Notebook: If you opt to perform an experiment in person, you will maintain a laboratory notebook for the experiment 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 Videos and Experiments: All experiment in the list above have been performed and recorded by Dr. Mitchell. These videos and the pertinent data will be available on D2L.

In-Person Laboratory Practices and Data Analysis: This section only pertains to students completing an experiment in person. You are **not required** to perform an experiment in-person but must let me know your choice on Day 1. If you decide to not perform the experiment, you can do so at **ANY time**, even on the day scheduled for you to conduct the experiment. In this case you will just use the video resource. If you decide later that you wish to perform an experiment in-person, accommodations may be made, but are not guaranteed due to scheduling complications.

The experiments that will be available to complete in-person are:

1) X-Ray Diffraction (MER114)
2) Sodium Doublet (MER114)
3) NMR (MER138)

This will be different than usual in that you will not be allowed to perform the experiment on your own schedule. You must make appoints to be in the lab room and will coordinate this with Dr. Mitchell. Only one student may perform an experiment in MER114 at a time. You are expected to follow all social distancing guidelines including wearing face protection and staying at least 6 feet from others when in the building. Should you need help with an experiment, Dr. Mitchell will be available remotely for the duration of your scheduled experiment time. If the problem can't be solved remotely, Dr. Mitchell will provide further guidance at the time.

All experimental apparatuses will be set-up for you, but you will need to do certain procedures such as alignment and calibration. You must develop your own procedures for conducting an experiment and analyzing the data. Although such procedures are often provided in equipment manuals, those procedures are often flawed or designed for instructional purposes. 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, cooperation, and consideration are critical to everyone's success.

Finally, take note that all of the experiments "work". That is, when all of the equipment is calibrated and when the experiment is executed properly, the experiment produces a result that is consistent with results published in the professional literature. If the value that you obtain for is not in agreement with (or consistent with) values published in the professional literature, you must take the following actions to discover what error has occurred and fix it. (1) Where possible, calibrate the equipment and make sure it is working properly (which you should have done before doing the experiment). (2) Check the equipment for defects and damage (which you should have done before doing the experiment). (3) Consult a faculty member regarding the procedure or the data analysis. (4) Ask me to check the equipment. **Do not disassemble or attempt to repair equipment.** Leave that to me. A paper or presentation in which the result is not in agreement with the literature will not receive a particular high score. Troubleshooting may take many hours, so it behooves you to plan far ahead and take good notes. NOTE: The Hall Effect is notorious for yielding results that are only consistent with the literature to within ~>5 values of the uncertainty. The percent error is typically between 10% – 75%. This is known, and reasonable results for this experiment will be acceptable. Again, please contact Dr. Mitchell with any concerns!

Bear in mind that professional scientists have no reference values against which to compare their results, but they do have extensive experience conducting experiments, and they execute their experiments with great care. In this class, you will be acquiring the kind of experience that allows you to execute experiments with great care, and one component of that experience involves comparing the results of your experiments to well established values in the literature. Because you know "the answer", you might be tempted to commit all kinds of terrible crimes against the data. You must be extremely careful not to introduce any bias in your work because you know the answer. Stay honest. I'm here to help when you get stuck.

Caring for Equipment: The equipment that you will use to conduct experiments during this course is quite expensive. The total cost for all the equipment in the lab exceeds $500,000. Single items can be quite expensive, too. For example, the Fabry-Perot etalon costs $3,500, the x-ray diffractometer costs $22,000 and the Princeton Instruments Pixis CCD camera costs $85,000.

Food and Drink are strictly prohibited in MER 114.

Upon the **first offense**, your access in-person privileges will be revoked.

Despite the high cost of the equipment, caring for the equipment requires no special training. Simply put, plan ahead. All of the manuals for the equipment in the lab are available on D2L, and all of the manuals describe how to handle the equipment safely. I expect you to read the manual for each piece of equipment from cover to cover before using the equipment. (The colloquial notion that "nobody reads the manual" is a myth. Read the manual!) Familiarize yourself with the equipment before using it. Create a "script" of all of the actions that you are going to execute during an experiment before you execute them. Review that script. Think about all of the ways you might harm the equipment before you take any action. When you are confident that your actions will not harm the equipment, then proceed with the script.

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.

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 π, are exempt from this rule.)

- Duplicate definition. (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, κ to represent the same spring constant.)

- Failure to report a numerical value for all of the physical quantities 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 10-20 minutes to comment on your first abstract before you submit it to me for a grade. 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 abstract. I will not review a draft that is incomplete or does not represent an authentic attempt to be complete. Failure to present a complete draft will also result in the loss of credit on the final draft of the abstract. A similar set of steps will occur for the final manuscript, but I will give 20 minutes to review the draft.

Welcome to Peer Review! For your second abstract, you will submit your drafts to a student peer, and we will discuss these during a class period. For your conference proceeding, you will do a peer review and will also get reviewed by a faculty member. You will have to respond to all criticisms via a response "letter to the editor" …namely me, and submit a revised draft.

NOTE: There is no draft for the FINAL PAPER, you will use all that you have learned from PHY310 and PHY320 to write this final research paper.

ZOOM-style Research Presentations: After your second experiment, you will give a talk describing your result to an audience of your peers and professional scientists, notably, the faculty in the Department of Physics on ZOOM. Your talk is limited to 15 minutes in a 20-minute time slot, leaving 5 minutes for questions. The faculty and I will provide additional written feedback on your presentation afterwards.

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

(1) Showing up…….	5%
(2) Conference Abstract…….	10% each
(1) Research Presentation ……	25%
(1) Conference Proceeding……...	25%
(1) Final Paper…….....	25%

I will assign each paper, abstract, and presentation a letter grade of A, B, C, D, or F, based on my professional judgment. (My grading criteria for the papers and presentations are articulated in the paper and presentation rubrics posted on D2L.)

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.

Guidelines for Office Hours: All office hours will take place on ZOOM. You set the agenda for office hours. You may attend in groups or as an individual.

Attendance: You are expected to come to every class and perform every experiment that you are assigned.

PHY320 Disclaimer - It is common for students to not attend other physics classes nor complete homework assignments due to time spent on PHY320 experiments, presentations or papers. This class is **NOT** an acceptable excuse to miss other courses, and I expect you will find time to complete all of the work assigned in your other classes.

Grading: A letter grade will be assigned based on performance in the course according to the following scale:

Grade	Quality Points	Percentage Equivalents	Interpretation
A	4.00	93-100	Excellent
A-	3.67	90-92	
B+	3.33	87-89	Superior
B	3.00	83-86	
B-	2.67	80-82	
C+	2.33	77-79	Average
C	2.00	73-76	
C-	1.67	70-72	
D+	1.33	67-69	Below Average
D	1.00	63-66	
D-	0.67	60-62	
F	0	< 60%	Failure

Refer to the Undergraduate Catalog for description of NG (No Grade), W, Z, and other grades.

Straight percentages will be given for all work, with the mid-semester and final grade based on overall class performance. Other considerations will influence your final grade including, class participation, class and laboratory attendance, and seeking timely guidance during office hours. Any student achieving at a level of 'C-' or below will be given an estimated grade on their mid-term deficiency grade report.

E-Mail and Communication: The best way to contact me is via e-mail. But, be aware that I will only read and respond to e-mails written in proper English, with correct grammar, spelling, and etiquette. Do not send me any e-mails addressed to "hey" or "yo," like you would text a buddy or close friend.

Boiler Plate Language Common to All WCU Syllabi

COVID-19 STATEMENT

Part of West Chester University's response to the COVID-19 pandemic was to switch the vast majority of instruction to remote. This decision was made out of an abundance of caution to protect the health of all members of the WCU community. Faculty have been asked to make every effort to adapt their courses to this novel situation while still meeting the critical learning outcomes of the course. Students are asked to discuss any problems with the new course format and schedule directly with their instructors. Patience and flexibility on everyone's behalf are critical to our community's navigation of this public health crisis.

ACADEMIC & PERSONAL INTEGRITY

It is the responsibility of each student to adhere to the university's standards for academic integrity. Violations of academic integrity include any act that violates the rights of another student in academic work, that involves misrepresentation of your own work, or that disrupts the instruction of the course. Other violations include (but are not limited to): cheating on assignments or examinations; plagiarizing, which means copying any part of another's work and/or using ideas of another and presenting them as one's own without giving proper credit to the source; selling, purchasing, or exchanging of term papers; falsifying of information; and using your own work from one class to fulfill the assignment for another class without significant modification. Proof of academic misconduct can result in the automatic failure and removal from this course. For questions regarding Academic Integrity, the No-Grade Policy, Sexual Harassment, or the Student Code of Conduct, students are encouraged to refer to the Department Undergraduate Handbook, the Undergraduate Catalog, the Ram's Eye View, and the University website at www.wcupa.edu.

STUDENTS WITH DISABILITIES

If you have a disability that requires accommodations under the Americans with Disabilities Act (ADA), please present your letter of accommodations and meet with me as soon as possible so that I can support your success in an informed manner. Accommodations cannot be granted retroactively. If you would like to know more about West Chester University's Services for Students with Disabilities (OSSD), please visit them at 223 Lawrence Center. Their phone number is 610-436-2564, their fax number is 610-436-2600, their email address is ossd@wcupa.edu, and their website is at https://www.wcupa.edu/universityCollege/ossd/. In an effort to assist students who either receive or may believe they are entitled to receive accommodations under the Americans with Disabilities Act and Section 504 of the Rehabilitation Act of 1973, the University has appointed a student advocate to be a contact for students who have questions regarding the provision of their accommodations or their right to accommodations. The advocate will assist any student who may have questions regarding these rights. The Director for Equity and Compliance/Title IX Coordinator has been designated in this role. Students who need assistance with their rights to accommodations should contact them at 610-436-2433.

EXCUSED ABSENCES POLICY

Students are advised to carefully read and comply with the excused absences policy, including absences for university-sanctioned events, contained in the WCU Undergraduate Catalog. In particular, please note that the "responsibility for meeting academic requirements rests with the student," that this policy does not excuse students from completing required academic work, and that professors can require a "fair alternative" to attendance on those days that students must be absent from class in order to participate in a University-Sanctioned Event.

REPORTING INCIDENTS OF SEXUAL VIOLENCE

West Chester University and its faculty are committed to assuring a safe and productive educational environment for all students. In order to comply with the requirements of Title IX of the Education Amendments of 1972 and the University's commitment to offering supportive measures in accordance with the new regulations issued under Title IX, the University requires faculty members to report incidents of sexual violence shared by students to the University's Title IX Coordinator. The only exceptions to the faculty member's reporting obligation are when incidents of sexual violence are communicated by a student during a classroom discussion, in a writing assignment for a class, or as part of a University-approved research project. **Faculty members are obligated to report sexual violence or any other abuse of a student who was, or is, a child (a person under 18 years of age) when the abuse allegedly occurred to the person designated in the University Protection of Minors Policy.** Information regarding the reporting of sexual violence and the resources that are available to victims of sexual violence is set forth at: https://www.wcupa.edu/_admin/diversityEquityInclusion/sexualMisconduct/default.aspx

EMERGENCY PREPAREDNESS

All students are encouraged to sign up for the University's free WCU ALERT service, which delivers official WCU emergency text messages directly to your cell phone. For more information, visit www.wcupa.edu/wcualert. To report an emergency, call the Department of Public Safety at 610-436-3311.

ELECTRONIC MAIL POLICY

It is expected that faculty, staff, and students activate and maintain regular access to University provided e-mail accounts. Official university communications, including those from your instructor, will be sent through your university e-mail account. You are responsible for accessing that mail to be sure to obtain official University communications. Failure to access will not exempt individuals from the responsibilities associated with this course.

Week	Schedule	Assignments
1.	**CLASSTIME:** ○ Lecture: Introduction/Overview. ○ What is an Experiment? ○ Choosing Experiments/Presentation Scheduling. **OTHER:** Perform the speed of sound experiment (Experiment #0)	Get a value for the speed of sound and an uncertainty. Compare to a theoretical model for the speed of sound.
2.	**CLASSTIME:** ○ Lecture: Scientific writing – Manuscript Abstracts and Introductions ○ Discuss the role of abstracts in science. ○ Review rubric for grading abstracts ○ Review student feedback procedure ○ Schedule instructor feedback meetings ○ Write a brief abstract on speed of sound and present to class. ○ Class discussion of brief abstracts.	Perform Experiment #1
3.	**CLASSTIME:** Lecture: Scientific Writing – Conference Abstracts and Conference Proceedings	Finish Experiment #1 (Friday) Submit abstract draft for Experiment #1
4.	**CLASSTIME:** Lecture: Scientific Talks (a) **OTHER:** Conduct Exp 2	Perform Experiment #2 Abstract Draft Review for Experiment #1 (Friday) Submit abstract for Experiment #1
5.	**CLASSTIME:** Lecture: Scientific Talks (b)	Finish Experiment #2
6.	**CLASSTIME:** ○ Lecture: Scientific Talks (c) ○ Discuss the role of peer-review in science and role of presentations. ○ Discuss the rubric for the presentations. ○ Peer abstract Review **OTHER:** Write and submit abstract for Exp 2.	Group #1 Prepare practice talks on Experiment #2 (Tuesday) Peer Abstract Draft Review for Experiment #2 (Due Friday) Submit abstract for Experiment #2
7.	**CLASSTIME:** ZOOM Practice Talks with Instructor/Peer Feedback	Group #2 Prepare practice talks on Experiment #2 (Due Friday) Abstract Experiment #2
8.	**CLASSTIME:** ZOOM Practice Talks with Instructor/Peer Feedback	Group #3 Prepare practice talks on Experiment #2
9.	**CLASSTIME:** ZOOM Practice Talks with Instructor/Peer Feedback	Revise Presentations for Formal Presentation
10.	**CLASSTIME:** ZOOM Presentations with Peers and Faculty	Start Experiment #3
11.	**CLASSTIME:** ZOOM Presentations with Peers and Faculty	Finish Experiment #3
12.	**CLASSTIME:** ZOOM Presentations with Peers and Faculty	Start Draft of Proceeding
13.	Peer Proceeding Review	(Due Monday) 1st Draft of Proceeding (Due Friday) Final Draft of Proceeding
14.	***NO CLASS: FALL BREAK!***	
15.	**CLASSTIME:** NONE **OTHER:** Write scientific paper on Exp 3	Write Final Paper
16.	**FINALS WEEK**	(by Mon) Submit Final Paper on Exp 3