PHY 310 – Intermediate Physics Lab: Experimental Methods & Scientific Communication

Fall 2022

Instructor Information

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Textbooks

Required Textbooks:

- Taylor, J. R. (1997). An Introduction to Error Analysis: The Study of Uncertainties in Physical Measurements. University Science Books
- Carter, M. (2020) Designing Science Presentations: A Visual Guide to Figures, Papers, Slides, Posters, and More. Academic Press
- Saramaki, J. (2018) How to Write A Scientific Paper: An academic self-help guide for PhD Students

Required Materials:

- A computer that can run Matlab
- A laboratory notebook

Recommended Textbook:

• Attaway, S. (2013). *Matlab: A Practical Introduction to Programming and Problem Solving.* Butterworth-Heinemann.

Software

This course relies heavily on Matlab. The University has a site license for Matlab making it free for all students. To install Matlab on your personal computer, use the <u>WCU portal on Mathworks</u>. If the email sent to you from MathWorks is significantly delayed, please reach out direction to MathWorks support (information provided in the link) and it will often be addressed immediately.

Course Descriptions

PHY310 is a lecture and laboratory course designed to familiarize students with performing experiments, analyzing results, and presenting findings in both written and presentation forms.

Overview of Course Activities

During this course, you will:

- Write and revise a scientific abstract.
- Write and revise a scientific report.
- Create and revise a scientific talk.
- Converse with fellow scientists about experiment design, data collection, data analysis, and drawing evidence-based conclusion.

- Conduct physics experiments that are thesis driven
- Conduct physics experiments that minimizing uncertainties (e.g. instrument, statistical, systematic)
- Draw evidence-based conclusions from data analysis.
- Utilize MATLAB to perform data analysis and generate graphs.

Speaking Emphasis Course

This course is designated as a Speaking Emphasis (SE) course in the WCU General Education Curriculum. As a Speaking Emphasis course, this course will focus on informal and formal discussions of scientific findings. Informal discussions will occur in 'group meetings' which are often utilized in research settings (both academic and in industry). Group Meetings are discussed further in the Pedagogical Tools section. The formal discussion will be a scientific talk presented to the department exploring a scientific question. Preparing your scientific talk will happen throughout the semester and includes these steps:

- (1) critically thinking about experiment design, data collection, data analysis, and evidence-based conclusions
- (2) taking part in informal conversations with classmates and instructor about these items during Group Meetings
- (3) learning about best practices for designing PowerPoint slides and presenting data
- (4) learning and practicing best practices for public speaking with focus on:
 - a. structuring the narrative of your talk
 - b. voice and delivery
 - c. body actions and motions
- (5) recording a video of your talk and receiving feedback from the instructor about voice, tempo, word clutter, and talk structure
- (6) giving a mock presentation of your talk to the class and receiving feedback from the instructor and your peers. Instructor feedback will focus on body actions and positioning, eye contact, and composure.
- (7) receiving instruction on how to handle the question and answer session at the end of the talk.

For some. giving a talk to the entire Department can be a terrifying experience. However, as is clear from the list above, you will work on your talk diligently throughout the semester and will be ready when the time comes! You will be provided with multiple opportunities to practice your talk, receive instruction, as well as feedback.

As a **speaking-emphasis course**, aspects of this course are directly linked to the general education goals at West Chester University. This course will focus on these two general education goals:

Gen Ed Goal: Communicate Effectively. This goal will be met by achieving the following learning outcomes:

- *Revise and improve written and/or presentations.* You will create and revise your scientific talk over the course of the semester. As discussed above, this will be an iterative process informed by the explicit instruction and feedback. This outcome will be assessed by tracking the evolution of your presentation over the semester.
- *Express oneself effectively in presentations.* You will demonstrate your ability to express yourself effectively by giving a scientific talk to the department of physics and engineering. The activities that will occur for you to prepare for the talk are discussed above. In addition, you will be provided with multiple opportunities during the semester to give informal presentations or engage in informal discussion about data collection and analysis. *Assessment*: This outcome will be assessed by giving a scientific talk to the

Department. Faculty in attendance will assess the effectiveness of the presentation using an assessment rubric shared with you.

Gen Ed Goal: Think critically and analytically. This goal will be met by achieving the following student learning outcomes:

Construct and/or analyze arguments in terms of their premises, assumptions, contexts, conclusions, and anticipated counter-arguments. (A) You will present you data analysis in your scientific talk. Ideally, your analysis will clearly show your approach to conducting the experiment, analyzing the data, and drawing conclusions. Depending on your experiment, you might also critique the published work based on your findings. The first four weeks of the semester will be focused on critically thinking about experiment design and analysis to prepare you for your scientific talk. (B) In addition, your talk will be followed by a ten-minute question and answer session in which faculty will probe your understanding of the science, explore your approach to the experiment, and challenge your data analysis and evidence-based conclusions. In preparation for these questions, you will prepare slides that will explain ideas or concepts you anticipate will be questioned. Assessment: This outcome will be assessed by attending faculty at your scientific presentation. Assessment rubrics utilized by the faculty will be shared with you to provide a clear picture of the expectations.

Writing Emphasis course

This course is designated as a Writing Emphasis (WE) course in the WCU General Education Curriculum. As a Writing Emphasis course, this course will focus on informal and formal writing that occurs in the discipline of Physics. A major activity for the course is the writing of a scientific paper through multiple drafts and explicit lessons on disciplinary conventions.

Writing-emphasis aspects of the course are directly linked to the general education goals at West Chester University. This course will focus on these two general education goals:

Communicate Effectively. To achieve this goal, this course will strive to achieve the following student learning outcomes:

- *Express oneself effectively in common college-level written forms*. Writing assignments will occur throughout the semester. Feedback and guidance will be provided often. The major writing assignment for this course is a research-style scientific report. More details can be found in the assignment sections. (Writing-Emphasis)
- *Revise and improve written and/or presentations.* One of the major assignments for this course is the writing of a scientific report. The creation of the scientific report will be an iterative process starting with critically thinking about your experiment. As you write your scientific report, you will be provided with multiple opportunities to receive feedback and revise. In addition, throughout the semester, you will receive summative assessments focused on elements of the scientific report. More details can be found in the assignment sections.

Think critically and analytically. To achieve this goal, this course will strive to achieve the following student learning outcomes:

• *Reach sound conclusions based on a logical analysis of evidence.* Your scientific paper will provide an excellent opportunity to demonstrate your ability to analyze collected data and draw logical

evidence-based conclusions. Throughout the course, you will be provided with opportunities to analyze data and make sound conclusions. In addition, you will receive feedback on your attempts. Summative assessments will occur throughout the semester starting with the overall arguments being made in the paper and ending with sentence-level and word-level assessment. More details can be found in the assignment sections.

Course-level Student Learning Outcomes

This course is designed to meet the following goals.

- 1. Students will be able to conduct physics experiments while minimizing uncertainties (e.g. instrument, statistical, systematic) as well as illegitimate errors
- 2. Students will be able to analyze data collected from physics experiments following the best practices of data analysis and draw evidence-based conclusions
- 3. Students will be able to convey the results of an experiment by oral presentations such as a poster or talk
- 4. Students will be able to convey the results of an experiment to a diverse audience and in a variety of written forms (e.g. experiment proposal, conference abstract, and formal manuscript).
- 5. Students will understand the experimental design process and be able to develop and convey the reasoning behind an experimental method.

Course Elements

Modern Physics Experiments

The science you will be exploring this semester has already been discussed in PHY 170, PHY 180, and PHY 240. The experiments, rather than serving as a pedagogical tool for learning scientific topics, will instead serve as a backdrop to explore conducting experiments and scientific communications. The experiments utilized this semester in PHY 310 are:

- Measuring Planck's Constant using the Photoelectric Effect
- Measuring the Molecular Polarizability of Air using a Michelson Interferometer
- Measuring the Charge-to-Mass Ratio of the Electron using the Bainbridge Apparatus
- Measuring the Energy Levels of Argon using the Franck-Hertz Experiment

Pedagogical tools

- *MATLAB Scripts* Students will utilize MATLAB script for data analysis and plotting. Scripts will be submitted via D2L and reviewed by the instructor.
- *Worksheets* Students will complete worksheets which aim to develop specific skills. The skills developed by the worksheets range from critical thinking, writing effectively, graphic design, or data analysis techniques. These skills will then be used in more formal assignments later in the semester.
- *Abstracts* Students will write and revise an abstract summarizing the results of an experiment. Abstracts will be used to develop a student's formal writing and begin to convey the style of writing in the discipline of physics.
- *Group Meetings* Group Meeting represent a common convention in science. A Group Meeting is when research team meets periodically (e.g. weekly or monthly) to informally discuss research projects. Lecture will sometimes take on the form of a group meeting in which students will share the progress of their experiments and discuss the next steps.

Major Assignments

• *Scenario Experiment* – The scenario experiment embeds an experiment into a hypothetical situation a student might find themselves in. The scenarios will provide students with a clear research question

and audience for their work. Student will need to think critically about the issue that needs addressing, derive a hypothesis, devise an experiment, analyze the results, and draw a conclusion.

- *Scientific Talk* Students will present the result of their Scenario Experiment in a scientific talk to the Department of Physics. The Department will play the role of the hypothetical audience discussed in the scenario.
- *Scientific Report* Student will write a scientific report stating the findings of the scenario experiment. The audience for the report will be discussed in the scenario. Explicit instruction will occur over the semester regarding the structure of the report, the expected disciplinary conventions to follow, and the appropriate level of critical thinking captured by the report.

Gen Ed Goal	Learning Outcome	Evaluation Activity
Communicate	WE: Express oneself effectively in	Writing exercises on worksheets (informal)
Effectively	common college-level written forms	Abstract on experiment #1 (formal)
		Scientific paper on scenario experiment (formal)
Communicate	WE: Revise and improve written	Three revisions of scientific paper
Effectively	and/or presentations	Feedback on experiment proposal and analysis
Communicate	SE: Revise and improve written	Three revisions of scientific talk
Effectively	and/or presentations	
Communicate	SE: Express oneself effectively in	Group meetings (informal)
Effectively	presentations	Scientific talk (formal)
Think Critically	WE: Reach sound conclusions based	Post-lab worksheets
& Analytically	on a logical analysis of evidence	Post experiment analysis and conclusions –
		worksheet
		Scientific paper
Think Critically	SE: Construct and/or analyze	Informal meeting with instructor to discuss
& Analytically	arguments in terms of their	experiment analysis and conclusions
	premises, assumptions, contexts,	Scientific talk with Q&A
	conclusions, and anticipated	
	counter-arguments	

Summative Assessments of Writing Emphasis (WE) and Speaking Emphasis (SE) Learning Outcomes

Coaching and Feedback

Receiving coaching and feedback will play a critical role in the development of your critical thinking about your experiment, writing your scientific report, and preparing your scientific talk. Below is an outline of the coaching and feedback you will receive through the semester.

Weeks 1 through 4

Critical Thinking: During the first four weeks of the semester, you will complete pre-lab and post-lab worksheets. The goal of these worksheets will be to promote critical thinking about the experiments. They will be graded with a quick turn-around time. If needed, you will be asked to revise the worksheet to improve the analysis. The revisions request will include prompts and recommendations to help promote critical thinking about the issue at hand.

Writing: Your first formal piece of writing will be an abstract submitted in week 3. Writing the abstract will provide an overview of the common content found in scientific papers. This abstract will be reviewed and returned to you for edits with resubmission due at the end of week 4.

Weeks 5 through 7

Critical Thinking: In your experiment proposal, you will need to think critically about your scenario experiment. You will capture your thinking and you proposed experiment on the 'Experiment proposal – worksheet.' This worksheet will be reviewed and returned to you for revisions as needed. The revisions request will include prompts and recommendations to help promote critical thinking about the issue at hand.

Critical Thinking: After conduction your proposed experiment, you will complete a post experiment worksheet in which you will share your analysis and conclusions.' This worksheet will be reviewed and returned to you for revisions as needed. The revisions request will include prompts and recommendations to help promote critical thinking about the issue at hand.

Writing: You will be explicitly taught about the style and voice found in scientific reports. A worksheet will be used as a formative assessment of your understanding of the key points and will be returned for revisions as needed.

Writing: You will be explicitly taught about paragraph structure found in scientific reports. A worksheet will be used as a formative assessment of your understanding of the key points and will be returned for revisions as needed.

Writing: You will be explicitly taught about sentence mechanics found in scientific reports. A worksheet will be used as a formative assessment of your understanding of the key points and will be returned for revisions as needed.

Weeks 8 through 10

Writing: You will craft the first draft of your scientific paper. Your paper will first be assessed for its thesis, organization, audience and development of evidence-based conclusions. Issues with these elements will be pointed out and you will need to revise and resubmit your work.

Speaking: You will be explicitly taught about structure of a scientific talk. A worksheet will be used as a formative assessment of your understanding of the key points and will be returned for revisions as needed.

Speaking: You will be explicitly taught about the voice and delivery of a scientific talk. A worksheet will be used as a formative assessment of your understanding of the key points and will be returned for revisions as needed.

Speaking: You will submit a narrated PowerPoint slides. Your submission will be reviewed with a focus on the quality of the slides as well as the voice, tempo, and word clutter of your delivery. Your submission will be assessed and feedback will be provided.

Weeks 11

Writing: You will craft the second draft of your scientific paper and submit. Your paper will be assessed for paragraph structure and sentence structure. Issues with these elements will be pointed out and you will need to revise and resubmit your work.

Speaking: You will be explicitly taught about body actions such as hand gestures and eye contact. A worksheet will be used as a formative assessment of your understanding of the key points and will be returned for revisions as needed.

Speaking: You will submit your slides for a second time for review. Your slides will be assessed and returned for revision as needed.

Weeks 12

Writing: You will be explicitly taught about word choice. A worksheet will be used as a formative assessment of your understanding of the key points and will be returned for revisions as needed.

Speaking: You will give a mock presentation of your scientific talk. Your talk will be assessed with a focus on body actions. Feedback will be provided for you to consider.

Speaking: Your slides will be submitted for a third and final review. Your slides will be assessed and returned for revision as needed.

Weeks 13

Writing: You will craft the third draft of your scientific paper and submit. Your paper will be assessed for word-choice as well as other glaring issues. Issues will be pointed out and you will need to revise and resubmit your work.

Speaking: You will give your Department presentation of your scientific talk. You will receive instructorlevel feedback about how you handled the question and answer session as well as department-level feedback from all faculty in attendance about your presentation.

Schedule

Week	Goals	Submissions
1-4	 Develop a comfortability with using MATLAB to perform error analysis and graphing of data Complete four experiments. For each experiment, you will: (a) critically think about the experiment design, (b) be able to describe the underlying theory, (c) collect data while minimizing uncertainties, (d) analyze the data, (e) interpret the data analysis and (f) drawevidence based conclusions. (Worksheets will guide you through this process.) 	Experiment #1 – prelab worksheet (includes MATLAB introduction) Experiment #2 – prelab worksheet Experiment #3 – prelab worksheet Experiment #1 – post-lab worksheet Experiment #2 – post-lab worksheet Experiment #3 – post-lab worksheet
	 Become familiar with the primary modes of writing in the discipline. Learn about conventions of a scientific abstract and practice writing and rewriting abstracts 	Abstract of experiment #1 Revised abstract of experiment #1
5-7	 Explore your Scenario Experiment Formulate a hypothesis and devise an approach to test your hypothesis Conduct your experiment, analyze the results, and draw conclusions. Learning about scientific reports style and voice in formal scientific writing. Complete writing-to-learn activities exploring common areas of growth for students, moves often made in scientific writing, how to structure a paragraph, and how to write a concise and precise sentence. 	Experiment proposal - worksheet Post experiment analysis and conclusions - worksheet Writing conventions – style and voice worksheet Writing conventions – paragraphs worksheet Writing conventions – sentence mechanics worksheet
8-10	BREAK Write and revise your scientific paper based on	Submit first draft of scientific paper
	teedback.	Talk conventions – structure

	 Become familiar with the primary modes of presenting in the discipline. Learn about voice and delivery of speakers giving scientific presentations. Create slides for presentation and record a video of presenting the slides. 	worksheet Talk conventions – voice and delivery worksheet Submit presentation slides Submit ten-minute video of your presentation.
11	 Complete polished draft of your scientific paper. Learn about body actions and motion of speakers giving scientific presentations. Practice presentation (recording and playing back) 	Talk conventions – body actions and motions worksheet Submit second draft of scientific paper Submit revised presentation slides
12	 Take part in a mock presentation session Revise slides and delivery based on feedback 	Take part in mock presentation Submit revised slides Writing conventions – word choice worksheet
13	 Present your scientific talk Make final edits to scientific paper 	Present scientific talk to department Submit third draft of scientific paper
14	 Record a video of your talk and upload to your ePortfolio Complete worksheet reflecting on the process of writing your scientific paper. Complete rubric grading your scientific paper Submit reflection, rubric, and final version of your scientific paper. Upload your final draft to your ePortfolio 	Writing process reflection - worksheet Grading rubric for scientific paper - worksheet Submit fourth draft of scientific paper
15	• Record a video of your revised talk and upload to ePortfolio and send link to instructor	

Evaluation & Grading

The weights for the graded items are:

Cumulative grade on experiment #1 abstract	5%
Weeks 1-4 worksheets	25%
Scenario Experiment design and execution	10%
Cumulative grade on scientific paper	30%
(6 worksheets, 10 points each)	
(4 drafts, 25 points each)	
Cumulative grade on scientific talk	30%
(3 worksheets, 10 points each)	
(slides with video, 15 points	
(2 revised slides, 5 points each)	
(2 live presentations, 15 points each)	

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

Grade	Quality Points	Percentage Equivalents	Interpretation
А	4.00	93-100	Excellent

A-	3.67	90-92	
B+	3.33	87-89	Superior
В	3.00	83-86	
B-	2.67	80-82	
C+	2.33	77-79	Average
С	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.

Attendance Policy

Attendance is required and critical to the success of the course. If absence is unavoidable, please email the instructor.

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 <u>ossd@wcupa.edu</u>, and their website is at <u>https://www.wcupa.edu/universityCollege/ossd/</u>. 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 email 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.

Bibliography:

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