DEPARTMENT OF PHYSICS UMBC
PHYS 122L: Introductory Physics Laboratory

Dr. Daniel Gonzales

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Lecture: M 1:00 - 1:50 pm Sondheim 110 §5, 6
Tu 1:00 - 1:50 pm Sondheim 209 §2, 3

Course Description

This 3-credit lab course is based on the physical phenomena associated with the PHYS 121-122 lecture-course sequence. The laboratory includes planning a measurement, setting up and working with equipment, and recording data. Students will learn to analyze data, compare theory with experiment, and estimate and report errors. Students will learn to present results in a complete, concise, and clearly written report.

Learning Objectives

In this course, you will learn how to apply the tools of statistics and error propagation to quantify the results of physical experiments that you will perform. Most of the physical phenomena explored in these experiments will have been introduced to you in Physics 121 and 122. The following are the learning objectives associated with this course:

- Explain the difference between systematic and random error
- Explain what instrumental limit error is and calculate it for digital and analog scales
- Report the measured value and uncertainty for a measurement
- Describe how many significant figures are associated with a measured value
- Statistically analyze a data set to determine the weighted mean; standard deviation; standard deviation of the mean; and total uncertainty
- Apply the principles of error propagation to determine uncertainties
- Graph data sets which should include: a title, labeled axes with correct units, error bars, best fit line, and equation for best fit line

- Perform a least squares fit for a data set to determine: slope and y-intercept of best fit line, uncertainty of the measured y-values, and the uncertainties of the slope and y-intercept
- Linearize a data set and perform the same least square fit analysis as above
- Make a quantitative comparison of an experimental result with a theoretically acceptable value

The rest of the semester will be spent on applying the theoretical principles your learning from PHYS 121/122 to experiments in the laboratory. The learning objectives associated with the experiments are:

- Observe physical phenomena familiar from your lecture courses. Become familiar with the intricacies of working in a lab, such as how to plan a measurement, how to set up and use equipment, and how to take and record data.
- Learn how to analyze your data and compare theory with experiment.
- Learn to present your results in the form of a written report and presentation.

It is absolutely OK to not understand some of the terms in the above learning objectives. We will of course cover some of these new topics in depth in the lectures.

Required Textbook

The required textbook is **An Introduction to Error Analysis** by John R. Taylor. The most recent edition is the third edition and is the "required" edition. However, I will be preparing my material from the 2nd edition. The 2nd edition is very good and only missing one advanced topic on Bayesian statistics from the 3rd edition that will not be covered in this course. I found some physical copies of the 2nd edition online for as low as $20. Digital copies are acceptable.

Taylor, is a very good book on statistical analysis. I have used it as a reference many times in my professional and academic careers. For students working towards careers in science and engineering, it is a good one to have on your bookshelf.

Prerequisites/Corequisites

Completion of PHYS 122(H) with C or higher or concurrent enrollment. You should have a good working knowledge of equations and concepts from PHYS 121 & 122 as well as knowledge of calculus (derivatives & integrals), trigonometry, geometry, and algebra.

Instructional Team

- **Instructor:** Daniel Gonzales: `DPGonzales@UMBC.edu`
- **TAs:**
  - Alaynah Shahid: `ashahid1@umbc.edu`
  - Eric Lowe: `elowe2@umbc.edu`

Course Structure

This course in designed to be taken *in-person* and is *not* a hybrid or remote course. All lectures will be held in person.

Weekly Schedule

- **Lectures:**
  - §5,6 M 1:00 - 1:50 pm Sondheim 110
  - §2,3 Tu 1:00 - 1:50 pm Sondheim 209
  - Instructor-led sessions whereby new material is presented. You are expected to have already done the reading.
- **Labs:** All labs will be held in PHYS 110.
  - §5 M 2:00 - 4:45 pm
  - §2 Tu 2:00 - 4:45 pm
  - §6 W 2:00 - 4:45 pm
  - §3 Th 2:00 - 4:45 pm
  - TA led sessions whereby students will perform their physical labs.
- **Office Hours:** All TA office hours and some of the instructor's will be held in the Physics Tutorial Center in PHYS 226A. Additionally, students are free to seek help from the tutorial center at any time, not just when the instructor, or TAs will be there. The hours of operation for the tutorial center are: Monday through Thursday, 12 noon to 5 pm.
  - Shannon: TBD
  - Eric: TBD
  - Instructor: Wednesday 1-2 pm & 3-4 pm
  - Instructor Non-PTC: Friday 8:30 - 10:00 am in PHYS 110
  - Additional appointments may be made with the instructor or TAs as needed.
- **Weekly Due Dates** See the **Tentative Class Schedule** section for details.
  - Almost all assignments will be due at the beginning of your lab session.
  - Exceptions will be clearly posted in the Blackboard Assignments.

Working in the Lab

Labs will be in Physics 110. No food or drink allowed in lab. Ordinarily, you'll work with one lab partner.

Be on-time; at the beginning of lab, TAs will check prelab (B steps marked in the lab manual) questions assigned. Those are worth 5 points of the lab's grade. Additionally, there is typically a $\sim$5-minute orientation to the apparatus that you shouldn't miss. Futhermore, some labs may require the whole lab period to complete. To enforce this students that show up late for lab, can

have penalties applied to the grade for that particular lab in the following manner: up to 5-15 min late: 10%; 15-30 min late: 20%; 30 min+ late: too late to participate (possible makeup lab with appropriate excuse

The instructions for the lab can be found in the lab manual located on Blackboard. You must record all your data, observations, calculations, and any variations from the standard procedure. Before leaving lab, you must have either the TA or instructor check you out to make sure you have collected all the correct data, checking out with the TA is worth 5 points toward the grade for your lab. They will also check to make sure your lab station is clean and tidy. Some short analysis will be done during the lab. However, you'll complete most of your data analysis after lab. If you finish a lab early, it may be worthwhile to begin the deeper analysis during the lab period. It's easier to get help, and you might realize you missed some important data needed in your analysis.

Lab Assignments

For all labs you will be submitting an analysis of each experiment which will include all the important elements of lab reports such as reporting data, discussion of results, and error analysis. The format is not as strict as a formal lab report and will be more like a series of questions you'll need to answer for each experiment. More details on these assignments can be found in chapter 0 of the lab manual.

Most labs will be physical experiments performed by the students in the laboratory. However, a few of them will be more like homework, where students will practice the concepts of statistics and analysis learned in the lectures. Whether it is a physical lab or homework, we will refer to all of these assignments as labs. In total, there will be ten of these labs throughout the semester. These labs will be worth a total of 60% of your instructor assigned grade.

For the physical labs, 5 points of the assignment's grade will be based on checking in with the TA or instructor at the beginning of the lab session. During this check-in the TA will ask to see your answers from some of the pre-lab questions (B steps marked in the lab manual). This check-in will be done at the beginning of each lab session.

Another 5 points of your grade for physical labs will be from checking out with the TA or instructor after you perform your experiments. Your lab table should be returned to a state similar to the beginning of the lab period. You will be expected to organize and clean up your lab table as a courtesy for the students in the following lab period.

These lab assignments will be due at the beginning of the lab period the week following the experiment. They will be collected at the beginning of the lab session by the TA. They should be typed, printed and stapled. More details can be found in the lab manual chapter 0.

You may talk to your classmates and lab partner regarding these assignments, but each of you must submit your own original text, graphs, and analysis. Copying someone else's work is cheating.

Formal Lab Reports

Two full formal lab reports will be due throughout the semester. These formal lab reports will be written about one of the physical labs performed throughout the semester. Each formal lab report is worth 5% of a student's final grade.

All standards for college-level writing will be adhered to for these reports. Reports must be typed using a word processor and should conform to the format supplied in the sample lab report. It must be spell-checked and written in clear English.

You may talk to your classmates and lab partner about lab reports, but each of you must submit your own original text, graphs, analysis, and report. Copying someone else's work is cheating.

Late Policy and Make-up Labs

Students can earn the ability to turn in ONE lab assignment late without penalty. The lab must be turned in on or before the lab period following the due date. To earn this ability, students MUST earn a 90% or more on the syllabus quiz located on Blackboard. Other than that, no late assignments will be accepted.

The deadlines for assignments are firm, and the above penalties will be applied for late submissions. However, please let me know as soon as you can of any documented extended illness or family responsibilities that may impact your ability to keep up in the class, and we will try to make a plan to keep you on track to succeed! There is a makeup week for labs near the end of the semester.

If you know in advance that you will miss a lab session due to a scheduling conflict, you may be able to make up the lab the same week. You must inform instructors and TAs at least 24 hours in advance of missing your assigned lab session *and* be able to attend a different lab session that same week. If you are unable to come in that week, there will be one week toward the end of the semester where any student can physically perform a missed lab.

Final Project

Most of the semester, you will be performing measurements and analysis on experiments which we prescribe for you, and for which the expected outcome is known. In contrast the last few weeks of the semester you will be designing and carrying out an investigation on a topic of your own choosing.

This project is worth a total of 30% of your final grade. This is a team project, and for the most part, the grade on this project will be shared by all students in the group. However, the instructor reserves the right to adjust these points for egregious instances of asymmetrical work and/or communication within the group. Not completing the final project will result in a failing grade for the course. No matter what grade the student has leading up to the final project. Additionally, for students who ghost their other group members may be at risk of failing the course.

The Elements of your independent investigation include:

Informal Proposal & Partner Contract: This proposal is a way to let the instructor know what you plan to do. The informal proposal should be a couple of paragraphs which broadly describe what physical concept you would like to test. It's best to give as much detail as possible on how you would like to perform this project. However, if you are mildly vague about what you want to do, that is OK. The informal proposal is worth one of the thirty percentage points for the final project.

After you submit your informal proposal, the instructor will meet with your group to get a better understanding of what you want to do. They will help the group come up with a more

concrete idea for an experiment to perform.

The contract part of this assignment will be an agreement between each student which outlines the responsibilities each partner owes to the final project. Included in this contract should be an outline of when certain portions of the project are due to each other. This will be used, along with any evidence, to resolve disputes between partners regarding accusations that a partner is not doing their part. Included should also be a plan/deadline for when a partner will raise any issue to the instructor.

Formal Proposal: After meeting with the instructor, you will be required to submit a formal proposal. This proposal should convey a very *clear* idea of what you want to test, the relevant physical theory/equations, how you will perform the experiment, and what materials you will need to perform the experiment. This proposal is worth four of the thirty percentage points for the final project grade.

Written report: Same as a regular full lab report that you will submit in weeks 7 and 11. Worth 15 of the 30 percentage points for the final project.

Presentation: 10 min presentation (8 min for your presentation, 2 min for questions). Motivate the question you asked, describe how you designed your experiment, and summarize your results and analysis. Include any lessons learned that you might apply next time. Worth 10 of the 30 percentage points for the final project.

Some general criteria: It doesn't matter how close you come to resolving the question you ask of nature – much more important is the process you took to attempt to answer the question, and, more importantly, how well do you communicate that process. Do you make a convincing case that your question is interesting and worthwhile? Do you make some use of the elements of planning measurements or data analysis that you've learned? Did you take advantage of feedback you received during planning? Do you show evidence that you've shared the work – taken the lead on some aspects, while checking on those aspects your partner has led?

Grading Policy

The standard 10% per letter grade scheme will be used. Below will be the following breakdowns with S representing the final score for a student in the class.

A	$S \geq 90\%$
B	$90\% > S \geq 80\%$
C	$80\% > S \geq 70\%$
D	$70\% > S \geq 60\%$
F	$60\% > S \geq 60$

The instructor reserves the right to curve the scale depending upon on overall class scores at the end of the semester. Any curve will only ever improve a student's grade.

The grade will count the assessments using the following proportions:

- **60%:** Labs
  - **6% ea:** 10 Labs total
- **30%:** Final Project
  - **15%:** Lab Report

  - **10%:** Presentation
  - **4%/1%:** Formal and Informal Proposal respectively

- **10%:** Formal Lab Reports
  - **5% ea:** 2 Reports Total. Resubmission opportunities will be granted for the first report.

All scores will be posted to Blackboard. It is the student's responsibility to check Blackboard to make sure that their grades are correct. If there are any errors, the student must contact their TAs immediately to resolve the problem. All posted scores become final one week after they are posted.

Technology Use:

UMBC requires all students to be technologically self-sufficient, which entails having a **reliable personal computer** (preferably a laptop with webcam) and **Internet access**. Since UMBC requires all students to have a computer and Internet access, financial aid may be used to meet this requirement. To learn more, students should contact their financial aid counselor at financialaid.umbc.edu/contact. In addition, the Division of Information Technology (DoIT) provides a wealth of resources and support, including tips for getting online and minimum specifications to consider when purchasing a computer (doit.umbc.edu/students).

- **Blackboard:** Assignments, class slides, lab notes, and announcements will be posted on Blackboard as well as your grades. It is your responsibility to keep up to date with the course materials and announcements posted on Blackboard.
- **Microsoft Word and Excel:** These programs are available for free to download as a UMBC student. The necessary features are available in desktop application version. **At some point, we will learn how to plot data with error bars. This is surprisingly difficult, if not impossible, with other spreadsheet applications, including the browser based version of Excel. You are free to use any spreadsheet application you want, but the instructional team cannot offer support for making plots in other applications. You'll be on your own.** Sorry for the bold font in the previous statements. I'm not trying to shout or be stubborn or inflexible. It really is just *that* difficult to make error bar plots in non-Excel applications. If your data evaluation required the use of a spreadsheet, attach it to your lab report. Incorporate only the main results and plots in the main text of the report.
- **Webex:** Options to meet with the TAs and/or instructor via Webex will be available. If for any reason we need to move to a fully remote course, Webex will be used for lectures and office hours. If this happens, details regarding the move to a fully remote course will be communicated to all students.

Academic Integrity and Honesty

All instances of academic misconduct will be addressed according to the UMBC Policy on Academic Integrity. Examples include attempting to make use of disallowed materials on assignments, soliciting help by posting material on the internet for any assignment, looking at posted

material from others online, altering graded work and submitting it for regrading, asking someone else to take an assignment in your place, copying another's work on an assignment, asking someone else to do an assignment and representing it as your own, permitting or assisting another student to carry out any of the above, or any other instance of academic misconduct. Penalties range from a grade of 0 on the assignment to an F in the course (at my discretion), and from denotation of academic misconduct on the transcript to expulsion (as determined by official hearing of the Academic Conduct Committee).

It is my firm belief that no student enrolls in a course with the intention of cheating their way through it. Rather, as a course progresses and a student falls behind their goals, they see cheating as a desperate resort to get back on track. If you find yourself in this situation, please reach out for help from the instructor and TAs. Every one of you can pass this course without resorting to cheating, let the instructional team help you out if you feel overwhelmed.

Contacts

- Contact your TAs with questions regarding grades or for general help.
- Contact the instructor, Daniel Gonzales (`DPGonzales@UMBC.edu`), for anything not satisfactorily handled above, complaints about TA performance or behavior, final grade inquiries, or suggestions for improvements to the lab curriculum.
- Please cc both TAs and the instructor on all emails, unless the subject is of a personal or private nature.

Tentative Course Schedule

Week Date	Lab Activity Lecture Topic: Taylor Reading	Assignment Due	Final Project Due
1 8/25	Short Week: No Classes Taylor Ch 1		
2 9/1	Short Week: No Classes Taylor Ch 2		
3 9/8	Thermal Lab Error Propagation: Ch 3	Uncertainties Lab*	
4 9/15	Statistics Lab* Statistical Analysis: Ch 4	Thermal Lab	
5 9/22	Resistance Lab Least-Squares Fitting: Ch 8	Statistics Lab*	
6 9/29	Linear Regression Lab* Least-Squares Fitting cont.	Resistance Lab	
7 10/6	**Atwood's Machine** Acceptability of a Measured Result: Ch 5	Linear Regression Lab*	
8 10/13	Weighted Statistics Lab* Weighted Statistics: Ch 7	Atwood's Analysis	Informal Proposal
9 10/20	Simple Harmonic Motion Experimental Design	Weighted Stats* & **Atwood's Report**	
10 10/27	Capacitance Lab Technical Presentations	SHM Lab	Formal Proposal
11 11/3	**Electron e/m Ratio** B-fields	Capacitance Lab	
12 11/10	Project Design & Prototyping Error Budget Analysis	e/m **ratio &** **Formal Report**	Prototyping
13 11/17	Project Execution Experimental Case Study		Execution
14 11/24	Thanksgiving Short Week: No Classes		
15 12/1	Project Presentations	Due Monday at Noon	Slides & Report
16 12/8	Project Presentations (as needed) Short Week		

* Non-physical Labs.

Accessibility and Disability Accommodations, Guidance and Resources

Accommodations for students with disabilities are provided for all students with a qualified disability under the Americans with Disabilities Act (ADA & ADAAA) and Section 504 of the Rehabilitation Act who request and are eligible for accommodations. The Office of Student Disability Services (SDS) is the UMBC department designated to coordinate accommodations that create equal access for students when barriers to participation exist in University courses, programs, or activities.

If you have a documented disability and need to request academic accommodations in your courses, please refer to the SDS website at sds.umbc.edu for registration information and office procedures.

SDS email: disAbility@umbc.edu

SDS phone: 410-455-2459

If you will be using SDS approved accommodations in this class, please contact the instructor to discuss implementation of the accommodations. During remote instruction requirements due to COVID, communication and flexibility will be essential for success.

Sexual Assault, Sexual Harassment, and Gender Based Violence and Discrimination

UMBC Policy in addition to federal and state law (to include Title IX) prohibits discrimination and harassment on the basis of sex, sexual orientation, and gender identity in University programs and activities. Any student who is impacted by sexual harassment, sexual assault, domestic violence, dating violence, stalking, sexual exploitation, gender discrimination, pregnancy discrimination, gender-based harassment, or related retaliation should contact the University's Title IX Coordinator to make a report and/or access support and resources. The Title IX Coordinator can be reached at titleixcoordinator@umbc.edu or 410-455-1717.

You can access support and resources even if you do not want to take any further action. You will not be forced to file a formal complaint or police report. Please be aware that the University may take action on its own if essential to protect the safety of the community.

If you are interested in making a report, please use the Online Reporting/Referral Form. Please note that, if you report anonymously, the University's ability to respond will be limited.

Notice that Faculty and Teaching Assistants are Responsible Employees with Mandatory Reporting Obligations

All faculty members and teaching assistants are considered Responsible Employees, per UMBC's Policy on Sexual Misconduct, Sexual Harassment, and Gender Discrimination. Faculty and teaching assistants therefore required to report all known information regarding alleged conduct that may be a violation of the Policy to the Title IX Coordinator, even if a student discloses an experience that occurred before attending UMBC and/or an incident that only involves people not affiliated with UMBC. Reports are required regardless of the amount of detail provided and even in instances where support has already been offered or received.

While faculty members want to encourage you to share information related to your life experiences through discussion and written work, students should understand that faculty are required to report past and present sexual harassment, sexual assault, domestic and dating violence, stalking, and gender discrimination that is shared with them to the Title IX Coordinator

so that the University can inform students of their rights, resources, and support. While you are encouraged to do so, you are not obligated to respond to outreach conducted as a result of a report to the Title IX Coordinator.

If you need to speak with someone in confidence, who does not have an obligation to report to the Title IX Coordinator, UMBC has a number of Confidential Resources available to support you:

Retriever Integrated Health (Main Campus): 410-455-2472; Monday – Friday 8:30 a.m. – 5 p.m.; For After-Hours Support, Call 988.

Center for Counseling and Well-Being (Shady Grove Campus): 301-738-6273; Monday-Thursday 10:00a.m. – 7:00 p.m. and Friday 10:00 a.m. – 2:00 p.m. (virtual) Online Appointment Request Form

Pastoral Counseling via The Gathering Space for Spiritual Well-Being: 410-455-6795; i3b@umbc.edu; Monday – Friday 8:00 a.m. – 10:00 p.m.