PHYS 122L
Introductory Physics Lab
Dr. Eric C. Anderson
UMBC•Spring•2020
Syllabus

The principle of science, the definition almost, is the following: The test of all knowledge is experiment. Experiment is the sole judge of scientific 'truth.' But what is the source of knowledge? Where do the laws that are to be tested come from? Experiment, itself, helps to produce these laws, in the sense that it gives us hints. But also needed is imagination to create from these hints the great generalizations—to guess at the wonderful, simple, but very strange patterns beneath them all, and then to experiment to check again whether we made the right guess. – Richard Feynman

•Getting ready•

Prerequisites•You must have completed Phys 121, and Phys 122 (or be enrolled in it this semester.)

Workload•Experience shows that success requires *at least 6 hours each week* of intensive effort outside of class. Be sure that you can dedicate the time and concentration required for success.

Blackboard (BB)•For access to course materials, your grades, helpful advice, and announcements. Log in at least once between classes.

Required items•Two-copy lab notebook, available at UMBC Bookstore. (You keep the originals; your TA will collect the duplicates.) Ask at the bookstore if you're not sure. Access to any calculus-based intro physics text. Access to *Microsoft Word and Excel* with option to print. Make sure to back up frequently and to have a plan B for printing. Difficulties with your computer are not an acceptable reason for a late report.

Class•T 1:00-1:50 PM in Sondheim 207 and weekly lab T or Th (check your schedule) 2:00-4:45 PM in Phys 110.

•Learning goals•

Prerequisite knowledge•Fundamentals from Introductory Physics I and II including Newton's laws, conservation laws, rotation, oscillations, DC circuits, magnetic forces and magnetic fields, and thermodynamics. Fundamentals of calculus.

Course goals:

Experimental and analytical skills•Develop an array of basic skills and tools of experimental physics and data analysis, including computers for the collection, analysis, and graphical display of data, troubleshooting, and the uncertainty associated with measurement, and mathematical modeling.

Conceptual learning•Reinforce introductory physics concepts in selected areas.

Understanding the basis of knowledge in physics•By observing phenomena, analyzing data, and developing mathematical models, recognize that experimental evidence is the basis of our knowledge of the laws of physics – physics is not merely a collection of equations and textbook problems.

Developing collaborative learning and communication skills•Develop expertise in clear, cogent written reporting of experimental design, observations, analysis, and conclusions, practice oral presentation skills, and practice collaboration in the context of experimental physics. (A recent survey by the American Institute of Physics survey indicates that physics graduates named cooperative skills and complex real-world problem-solving skills as the two most vital skills in their professional lives.)

The art of experimentation•Through an independent investigation, begin to formulate questions of nature and apply experimental methods to make progress toward finding an answer.

•Methods•

Weekly Quiz•50 min quiz given in class each lab week. Open-book (LabPack) but *not* open notes. Collaborate with your lab partner or larger groups. Complete in your two-copy lab notebook (submit copy, you keep original). Prepare by reading the associated lab, reviewing relevant physics principles using your PHYS 121 or PHY 122 materials, and if desired, examining the sample quiz posted on BB Fri 5 PM of previous week. *First week* (due BEFORE start of first class): complete Syllabus Quiz on BlackBoard under *Syllabus*.

Homework•Two homework assignments, based on Ch. 0 of LabPack and the first and second weeks of class and lab time. Find on BB under *Course Documents*. Expect to spend an average of at least 6 hr on each homework assignment. Start early so that you can get help in office hours. Homeworks count for a significant chunk of your course grade and *help to build essential skills for lab reports*; completing a homework very late or poorly will leave you ill-prepared to achieve passing grades on your lab reports.

For any solution that requires calculation in Excel, include a printout of the results with the main answer circled or highlighted. Include handwritten comments on your printout to make it easier to follow. For other questions, homework solutions can be handwritten, but write clearly and be organized. You are encouraged to collaborate, but eventually each student must have her/his own unique solution.

Lab•Ordinarily you'll work with one partner. Be on-time; at the beginning of lab there may be a brief orientation to the apparatus that you shouldn't miss, and sometimes presentations by your peers. Late penalties: up to 15 min late: 10%, 15-30 min late: 20%, 30 min+ late: too late to participate (possible makeup lab with appropriate excuse.) Bring your two-copy lab notebook. Record all raw data and any variations from the standard procedure. Submit the copy before leaving. You'll complete most of your data analysis after lab, but time permitting, get started on it during lab. It's easy to get help and you might realize you missed some data. Email yourselves the Excel file for any analysis that you began.

Formal lab reports•Ultimately, success in achieving laboratory goals is demonstrated by communicating results. Formal lab reports must be typed and should follow the format given in the annotated *Sample Report* in the LabPack. Hard copy of your report is due at the beginning of the next lab. It's expected that you'll work with your partner or other classmates on your reports, but each of you ***must submit your own original text, graphs, analysis, and report***. If your data evaluation required the use of a spreadsheet, attach a printout to your lab report. Incorporate only the main results and plots in the main text of the report. Copying someone else's work is cheating. If your report is too similar to someone else's work – from your class or from a previous semester – you will get zero for the report. Be prepared to provide an electronic copy of your report for electronic comparison using SafeAssign, in case of any suspicion. Of course, it is understood that the raw data of your partner equal yours. But the evaluation, graphs and the text must be clearly different.

Refer to *Formal lab Report Grading Guide* under Course Documents in Blackboard for detailed grading criteria. Here are some of the important elements:

- All analysis detailed in the Lab Pack
- All conceptual questions are answered in the analysis/conclusion
- "Quality of language" means it is objective, precise, and concise (in addition to being proper English). Avoid rambling and vague phrases like "human error"
- Logical organization and flow
- Error evaluation in your report:
- Apply what you learned in lecture-- always include error, correct sig figs, etc.
- Describe the error method: "s.d. of mean", "added in quadrature", "I used ___ function in ___ program"
- In the APPENDIX, include error propagation formulas (esp. ones that use partial derivatives). You can also attach Excel tables (printed out or pasted in). If you do some extended analysis, derivations can go here, too.
- ILE can usually be stated once: "All values in this table..."
- Figures and Tables:
- No ambiguity-- include labels, captions and units!
- When plotting data, it should come with error bars. This can be individual measurement error, or it can be error from the least squares fit (Z parameter). Always specify.

Informal lab reports•Your experience writing *formal* lab reports is meant to build skills required to write a scientific paper in a peer-reviewed journal. But often scientists share the results of their research more informally, such as through email communications. It's a much faster mode of dissemination and it may afford a researcher rapid feedback that can help shape a formal journal submission. You'll be communicating the results of two of your experiments by writing such i*nformal* lab reports, to be submitted electronically in pdf format through BB.

Think of your audience as a colleague who's doing well in this course but missed this particular experiment. You want them to learn all about it and perhaps even offer you some useful feedback. Let them know exactly what you did and why, your results, what it all means, and what problems came up and how you addressed them. Clip in any needed figures, tables, or graphs. As for formal reports, be sure to address all of the questions in the lab pack. An example is posted on BB.

Oral presentation•Another mode of scientific communication is the 10-minute talk, typical of scientific conferences. You'll communicate the results of one of your last experiments (and also your independent investigation) via an oral presentation. You and your lab partner will share in your presentation to me and to a few of your peers who *haven't yet completed your lab*. Expect, possibly, questions during your talk, and a 2-minute question and answer period after your talk. It's fine to use notes, but don't rely on them too heavily and don't read from them. It should be apparent that you and your partner shared in the analysis and preparation. Aim to share equally in the oral presentation. Your report should include:

1. An overview of what the experiment is all about, and its significance: why should anyone want to do it? How does it fit into the big picture of physics?
2. Give a description of the basic physics necessary to understand the experiment. Don't derive any of the mathematical details, but be prepared to say where each relevant equation comes from, if it will help the listener understand the physics (how you do the derivation, but don't actually do it). It is important to write the equations that are used to interpret the experimental results, to state the assumptions made in obtaining the equations, and to explain in qualitative terms what these equations mean.
3. Give a description of the equipment and the experimental procedure, along with a diagram if helpful. Be sure that you understand in general terms what each piece of equipment does, and that you have some idea of how it works.
4. Experimental results. Present the results (don't forget uncertainty!) in the form of tables, or better yet, graphs. It's not necessary to present the raw data. Address questions given in the Lab Pack. Compare the experiment with theory if appropriate.

Along with your talk, please submit a paper copy showing your data analysis, e.g., Excel pages showing data tables, determinations of uncertainty, etc. I've posted the grading guide along with a few helpful resources on scientific talks in general under Course Documents.

Independent investigation•Most of the semester, you'll be performing measurements and analysis which we prescribe for you, and for which the expected outcome is known. In contrast, you'll spend the last few weeks of the semester with a partner in uncharted waters, designing and carrying out an investigation on a topic of your own choosing, thereby gaining a better sense of the nature of experimental physics. To find a partner, have informal discussions with your classmates throughout the semester, post your ideas in the *Ideas for Independent Investigation Topics* Discussion Board on BB, and respond to others' posts.

Elements of your independent investigation include:

Informal BB post: At least one post describing one or more ideas for a question to explore and one reply offering thoughtful feedback (10% of independent investigation grade).

*Proposa*l. A few paragraphs addressing (1) what you want to do and why, and (2) how you plan to carry it out (both collection and analysis of data), and (3) equipment requirements. Also include a rationale if you propose a solo project or to work with a group of three. Submit pdf on BB. I'll offer written comments that you'll be expected to respond to going forward. (20% of independent investigation grade.)

Written report. Typewritten, a few paragraphs including names and (1) a summary of what you proposed, what you carried out, and key results; and (2) a reflection on the process (did you learn something about experimental physics? the nature of science?) (20% of independent investigation grade)

Oral presentation: 12 min presentation (10 min, 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. (50% of independent investigation grade, evaluated by instructors and classmates)

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. 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?

•Policies•

Grading•Your grade consists of 12 equally-weighted parts: Each of two homework assignments, each of five formal lab reports, each of two informal lab reports, your oral presentation on one of the eight labs, your independent investigation, and your quiz average. 89.5% required for A, 79.5% for B, 69.5% for C, and 59.5% for D.

Late submissions•May be turned in to the Physics Department Office (Physics room 220) or directly to the TA or instructor. The score on a late assignment will be reduced according to the formula:

$$\text{Final Score}(t) = \text{Original Score} * 2^{-t/7},$$

where t equals the number of full or partial work days by which the assignment is late. Example: 1 day late ≈ 10% reduction.

Missing a lab•If you must miss a lab due to officially sanctioned UMBC activities, illness, family emergency, detention by authorities, or another difficulty, contact me as soon as possible. At my discretion, I'll request written verification of the cause of your absence and arrange for you to make up the lab during the week of 15-19 Apr.

Academic integrity•"By enrolling in this course, each student assumes the responsibilities of an active participant in UMBC's scholarly community in which everyone's academic work and behavior are held to the highest standards of honesty. Cheating could result in disciplinary action that may include, but is not limited to, suspension or dismissal." More on the requirements of academic integrity can be found at http://www.umbc.edu/gradschool/procedures/integrity.html

•Getting help•

Contact me•Eric C. Anderson, Physics 320. Office hours M 1:00-2:00, T 12:00-1:00, Th 1:00-2:00 in Phys 226A through 12 May. (Check BB for updates.) Phone 455-5823, email andersoe@umbc.edu. Please email me through BB or use your UMBC email and give your full name and your class. *If you seek help with the content of the class or have a general course question, please post to the appropriate discussion forum on Blackboard, so that others might benefit*.

Troll the discussion board•Post a question to a forum on Blackboard, or post an answer to another's question.

Drop by the Physics Tutorial Center•Physics 226, open 12-5 Monday through Thursday. Staffed by instructors and graduate TAs

Student Disability Services (SDS)•UMBC is committed to eliminating discriminatory obstacles that may disadvantage students based on disability. Services for students with disabilities are provided for all students qualified under the Americans with Disabilities Act (ADA) of 1990, the ADAAA of 2009, 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 would allow for students to have equal access and inclusion in all courses, programs, and activities at the University. If you have a documented disability and would like to request academic accommodations, please refer to the SDS website at sds.umbc.edu for registration information and to begin the process, or alternatively you may visit the SDS office in person in the Math/Psychology Building, Room 212. For any questions or concerns, you may contact us through email at disAbility@umbc.edu or phone at (410) 455-2459. If you require accommodations for this class, please visit me during office hours to discuss your SDS-approved accommodations.

●Day-by-day guide●

Week of:	**Quiz** 1:00-1:50 PM Tue in Sond 207	**Lab** 2:00-4:45 PM Tue OR Thur in Phys 110	**Due** 2:00 PM Tue OR Thur (in lab)
27-31 Jan	Syllabus Quiz due BEFORE start of class (find on Blackboard under *Syllabus*) Uncertainty	Uncertainty	
3-7 Feb	No quiz Modeling	Modeling	HW 1
10-14 Feb	Group A: Lab 1 Atwood's machine Group B: Lab 2 The ballistic pendulum	Group A: Lab 1 Atwood's machine Group B: Lab 2 The ballistic pendulum	HW 2
17-21 Feb	Group A: Lab 2 The ballistic pendulum Group B: Lab 1 Atwood's machine	Group A: Lab 2 The ballistic pendulum Group B: Lab 1 Atwood's machine	Lab 1/2 Formal lab report
24-28 Feb	Group A: Lab 3 Oscillatory motion Group B: Lab 4 Rotational motion	Group A: Lab 3 Oscillatory motion Group B: Lab 4 Rotational motion	Lab 2/1` Formal lab report
2-6 Mar	Group A: Lab 4 Rotational motion Group B: Lab 3 Oscillatory motion	Group A: Lab 4 Rotational motion Group B: Lab 3 Oscillatory motion	Lab 3/4` Formal lab report
9-13 Mar	Group A: Lab 6 Thermal properties of materials Group B: Lab 7 Ohm's law and resistivity	Group A: Lab 6 Thermal properties of materials Group B: Lab 7 Ohm's law and resistivity	Lab 4/3` Formal lab report
16-20 Mar			
23-27 Mar	Group A: Lab 7 Ohm's law and resistivity Group B: Lab 6 Thermal properties of materials	Group A: Lab 7 Ohm's law and resistivity Group B: Lab 6 Thermal properties of materials	Lab 6/7: Formal lab report

30 Mar-3 Apr	Group A: Lab 8 The current balance Group B: Lab 9 The measurement of e/m for the electron	Group A: Lab 8 The current balance Group B: Lab 9 The measurement of e/m for the electron	Lab 6/7: Informal report (submit on BB) BB Post "Ideas for ind. inv. projects" (by 5 PM Fri)
6-10 Apr	Group A: Lab 9 The measurement of e/m for the electron Group B: Lab 8 The current balance	Group A: Lab 9 The measurement of e/m for the electron Group B: Lab 8 The current balance	Lab 8/9: Oral presentation
13-17 Apr	No meetings	Makeup labs Independent investigation	Lab 9/8: Informal report (submit on BB) Independent investigation proposal
20-24 Apr	No meetings	Independent investigation	Makeup labs due
27 Apr-1 May	No meetings	Symposium – Oral presentations on independent investigations	Written report: Independent investigation
4-8 May	No meetings	No meetings	
11-15 May	No meetings	No meetings	