AUGUSTA UNIVERSITY
PHYSICS 1111L – GENERAL PHYSICS I LABORATORY - SPRING 2021

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Welcome to General Physics lab! This course is designed to guide your learning of fundamental concepts of experimentation, data collection and data analysis in the physics laboratory. These lessons will be delivered through hands-on experiments typically dealing with how and why objects with mass move and interact with other objects. And although the typical student in PHYS 1111L may not intend to become a practicing physicist, everyone can share an appreciation of the scientific process. The hope is that you will walk away at the end of the course having developed an appreciation not only for some of the techniques you have learned, but also what is means for a scientist to claim they "know" something based on experimentation.

Physics is an experimental science and this course (PHYS 1111L) is designed to provide an introduction to laboratory techniques which will be focused on experiments dealing with forces, masses, and motion. The process of using a set of tools to acquire physical data and then analyzing that data to reach conclusions is fundamental to most subject areas and courses that you may take later.

However, the primary purpose of PHYS 1111L is NOT to duplicate concepts discussed in the lecture portion (PHYS 1111) of the course. While reinforcement is beneficial and intended, the lab course is independent of the lecture and will cover additional independent concepts. The topics covered during the lecture serve as examples that we can explore in lab to learn how to trust and believe in those physical principles. The schedule of material in each lecture may not correspond directly with the material in lab which, as has been said, will focus on observing and measuring physical phenomena. The courses complement one another but will seldom track each other.

Course Objectives: The objectives of the laboratory portion of your PHYS 1111 course are for you to:

1. Develop experimental and analytical skills useful in the physics laboratory. This will include learning lab skills for building physical experiments.
2. Reinforce select concepts of physics through experiential learning.
3. Learn and appreciate the role of direct observation and measurement as the basis for knowledge in physics.
4. Keep an accurate record of your work in a laboratory notebook.
5. Analyze data and draw conclusions.
6. Describe and compute uncertainty in physical measurements.
7. Gain a basic level of familiarity with assembly, programming and use of motion and force sensors. This will include an introduction to circuit construction using breadboards.
8. Develop basic proficiency in use of hand tools including hammers, screwdrivers, wrenches, and electric drill.
9. Present data and results in a clear and logical manner.

What to Bring to Lab:

1. Pre-lab assignment.
2. Arduino kit. *See below for more details.*
3. Laboratory notebook. Your notebook should be quadrille ruled and bound. This notebook will be your most reliable long-term memory of what you did in lab and should include instructions that are complete enough so you could use just this book to reproduce your work. *See below for more details!*
4. Scientific calculator. (Cell phone "calculators" don't really count.)
5. Ink pen.
6. Laptop computer.

What to bring to lab:

- Pre-lab assignment
- Arduino kit
- Laboratory notebook
- Pen
- Calculator
- Laptop computer

Laboratory Components: There are five components as follows:

1. Pre-labs: For most of the laboratory experiments there will be a pre-lab exercise due at the beginning of the lab period. The pre-lab exercises introduce or reinforce concepts or techniques you will need to work proficiently in the lab and may require you to review select textbook readings or short video lessons. The purpose of each pre-lab exercise is to prepare you for the lab, not to stump you. In addition to a written pre-lab exercise, some lab sessions will begin with a short quiz to gauge your preparation. Missing or late pre-lab exercises or quizzes will receive zero credit.

2. Experiment: At the beginning of each lab period, the lab instructor will generally give a brief description of the lab procedures and objectives. This will often include instruction on proper lab techniques, safety considerations, lab equipment and supplies. Because this discussion occurs at the beginning of the lab period, it is imperative that you arrive to lab on time.

During the lab period you will need to record your data and observations in your lab notebook. Anything and everything you would need to reproduce your work should be included in your lab notebook. You will also want to "push your numbers through" so that you know your final result is reasonable. There's nothing worse than taking faulty (or incomplete) data only to discover your error days later when you begin writing your report.

3. Lab Summary: A written summary report will be required for most of the lab experiments. In most cases this will involve submitting a hard copy of your laboratory notebook pages. These are generally due at the beginning of the next lab period. In some cases you will be asked to present your work to the class in which case you should submit printed slides to the lab instructor.

Your report will be graded based on *completeness*, *correctness* and *originality*. It will also be graded based on how easy it is to read and how well it flows. Difficult to read reports or reports with major flaws will be given lower grades. And while you are encouraged to collaborate with others in the class, your writing and lab notebook must be your own.

Doing the minimum in the lab will generally earn you about an 85% for that experiment. In order to achieve higher marks, you'll need to explore some aspect of the lab in more depth. Suggestions for such "above and beyond" will be offered by the instructor.

Summary reports submitted late may be reduced in grade. Missing lab reports will receive negative grades.

4. Laboratory Exam: There will be a final laboratory examination which will test the practical skills you will learn during lab periods. Some data analysis may also be required. During the laboratory exams you will access to your laboratory notebook so complete and carefully written work will be of great value to you.

5. Extra Credit: There will be several opportunities for extra credit during the course. These opportunities will involve additional experimental exploration of a topic related to either the lecture portion of the course (PHYS 1111) or some aspect of the lab itself. Extra credit work will generally involve work with the Arduino microcontroller.

Laboratory Grading:

- Pre-lab Assignments: 20%
- Lab Summaries and Project Reports: 60%
- Laboratory exam: 20%

Expectations:

1. **General**
   - Be proactive in understanding what is needed to do well in lab. Ask questions when you don't understand something.
   - Bring all needed materials to each lab: pre-lab exercise, Arduino kit, writing materials, calculator, and lab notebook.
   - Pay close attention to the introductory comments and instructions provided by your lab instructor.
   - Report broken equipment to your lab instructor.
   - Leave your area neat, clean and organized.
   - Arrive on-time with a can-do attitude. There will be times when things don't work the first time (this is the real world of lab so get used to it); keeping a positive outlook and avoiding frustration are important for a good lab experience.

2. **Experiments**
   - Read all lab handouts before coming to lab. Enter procedures and other necessary information into your lab notebook. You should not need to rely on the lab handout during lab.
   - Submit your pre-lab exercise at the beginning of the lab period.
   - In many lab experiments you will form small teams. Each student must participate in all aspects of the experiment. It is not acceptable to break an experiment into sub-tasks to be performed separately.
   - Several lab experiments involve project work and will likely involve some design, testing and fabrication work outside of normal lab times. While this may sound like extra work (it is) it may also prove to be one of the most satisfying aspects of the course.

Date	Experiment/Lab Activity
12 Jan	Syllabus Review, Arduino Blink
19 Jan	Measurement uncertainty, Arduino Reaction Timer
26 Jan	Arduino Sonic Ranger, Measuring motion and speed.
2 Feb	Arduino Sonic Ranger, Motion diagrams, Acceleration of a ramp, *PLX-DAQ*
9 Feb	Projectiles 1: Building spring launchers, video tracking
16 Feb	Projectiles 2: Spring launcher testing and calibration
23 Feb	Projectiles 3: Target challenge!
2 Mar	Modeling Drag Forces
9 Mar	Measuring force, Arduino Load Cells
16 Mar	Jump Lab
23 Mar	Conical Pendulum, video tracking
30 Mar	Collision in One Dimension
6 Apr	MASTERS – *No Lab*
13 Apr	Rotational dynamics and Moment of Intertia
20 Apr	Oscillation measurements
27 Apr	Final Lab Exam

Arduino

In this class you will have the opportunity to use an Arduino microcontroller to collect data and control various systems. An Arduino can be thought of as a mini-computer which we can program to collect data from a sensor and/or control something. Thus, you will get some exposure to programming which is a powerful tool in any STEM field.

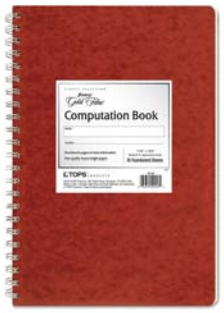
As such, for every class, you will need to bring your own laptop computer and you will need to carry out the following tasks ***before our first class***.

1. Purchase an Arduino starter kit. This kit includes extra elements that will be used in the class. If you already have your own Arduino, make sure it is an Arduino Uno, and that you have a full set of all of the elements that are in the Arduino kit (speakers, breadboard extender, etc.), as our wiring diagrams will be written for the Arduino Uno and we will be using various elements included in the Arduino kit. You can buy the Arduino Kit for about $30 from Amazon. Go to **amazon.com** and search for "*ELEGOO UNO Project Super Starter Kit*" to find the right kit.
2. Go to `www.arduino.cc` and download[1] the Arduino Integrated Development Environment (`Arduino IDE`) onto your laptop.

Laboratory Notebook

Physics is an experimental science. Experiments are done, observations are made, recorded and interpreted, and new experiments are designed based on those results. Without a carefully written lab notebook, we wouldn't know what we have done or where we are going.

But what should a good lab notebook look like? What information should be included in it? Well, basically, a perfect lab notebook would provide all of the information another person well-versed in physics would need to reproduce your work without referring to any other written resources. Here are some suggestions and "rules" which follow from this basic idea. These are in no particular order of importance, but should be followed when using any lab notebook[2].



- Your notebook should be permanently bound (search "**`Ampad Computation Notebook`**" on Google[3] to see my personal choice which is also shown in the figure to the right!). I like spiral bound notebooks because they "lay flat" so it's easier to write in them (and easier to photocopy!). No pages should ever be removed from the lab notebook.
- Leave a few pages blank at the beginning of the notebook so you can include a **`Table of Contents`** which you should update when starting each new experiment.
- Add the date to each new topic in your lab notebook.
- Electronically printed data tables or plots should be cut and taped into your lab notebook. You may also need to cut and tape electronic component data sheets into your notebook.
- Record the Title and Objective of each experiment at the beginning of each new experiment.
- Include sample calculations in your laboratory notebook.
- Circuit diagrams are necessary in a good lab notebook. This must include component values, pin diagrams and so on. Remember that your notebook should be complete enough so that someone could reproduce your work using nothing else.

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[1] For free!!!

[2] By the way, learning to keep an excellent lab notebook will prepare you for more advanced laboratory courses, graduate programs and even work in an industrial or scientific laboratory setting. This will save your employer time, effort and heartache and thus represents a competitive advantage over others applying for the same job you want.

[3] While you can find these with a quick Amazon search, you'll actually find them less expensive at places like **`OfficeSupply.com`**. Don't be that lazy Amazon shopper!

- Also include procedures and observations you make. Include units where necessary. Don't try to save paper…start a new page for each new experiment you perform[4].
- Don't fall behind keeping your lab notebook up to date. Keep up on it!
- Since your lab notebook is a permanent record you should only write in pen. Black pen is preferred.
- Never use white-out. Cross out any mistakes using a single line through it. Don't completely obscure your mistake as it might come in handy later. You may want to include a brief text note indicating what you believe the error was.

Metric	Requirements
Pen	Write in ink, not pencil
Date	Date every page at the top
Right Side	Begin each experiment on right hand page.
Legible	Neat, clean, easy to read.
Mistakes	Mistakes are crossed out with a single line.
Organized	Table of Contents Title of Each Experiment Objectives of Each Experiment Clear what is being done
Informative	All required data and information is included Descriptive comments of observations are included

[4] I personally tend to use only the front of each page.