Physics 22
Introductory Physics Lab II

Fall 2018

Welcome to Physics 22. This is your syllabus which tells you what this course is about and provides an overview of what you will learn. It contains the details of how your work will be graded throughout the course as well as information on the material and objectives you will cover. This syllabus is a guide to what we will cover this semester. It is subject to change, depending on the progress we make or any issues that we may encounter throughout the course of the semester. If there are any questions about the syllabus, contact me as soon as possible.

Class Times: 3 hour lab period once per week (time slot is determined by your section number.)
Location: LL 206 or LL 207

Contact Information

Head Instructor: Paul V. Quinn Sr.
Email: pvq2@lehigh.edu

Please fill in the table below with the appropriate information in regards to your lab section and your lab instructor

Section Number	Lab Instructor	Instructor Contact Information

Required Materials

1) Our local Physics 22 lab manual (available at the bookstore):
   Physics 022 - Introductory Physics Lab II - Laboratory Instruction Manual.
2) The assigned laboratory notebook from the bookstore (#77648 or equivalent sewn binding).
3) Scientific calculator.
4) Metric ruler.

Contents

Physics 22 , "Introductory Physics II Laboratory" is the one-credit laboratory portion of the second semester of Lehigh University's two-semester introductory physics sequence. In Physics 22, we cover three broad subject areas, electromagnetic phenomena, waves, and optics. Specific experiments include working with electric fields, capacitors; oscilloscopes, AC circuits, an amplifier, converging lenses, 2-lens systems, a prism, diffraction gratings, the mass of an electron, waves, the photoelectric effect, and the double slit experiment.

Prerequisites/Corequisites

Physics 22 requires prior credit for Physics 12 Lab and simultaneous enrollment in an accompanying lecture course for second semester introductory physics, Physics 21 or Physics 13.

Relationship of This Lab to Physics 13 and 21

It is impractical and unnecessary to arrange that each experiment be done in the same week as the related material is studied in Physics 13 or 21. In most cases you will encounter each new physics principle in the lab first. If your lab notebook is clearly written, you will be able to draw connections between lab and class work as you cover the material in your textbook. However, most of the experiments are designed to introduce you to the equipment that is used to measure electromagnetic and optical phenomena.

Course Objectives

The goal of this course is to introduce students to laboratory procedures and help them to learn to keep an accurate record of their experiments and results. Laboratory work is an essential part of science because it is how we test hypotheses and theories to determine which ones best describe observations in the natural world. The more accurate the test, the more confidence we have in its results. Thus, we develop laboratory techniques and skills to perform experiments with the highest possible degree of accuracy. In many of the experiments you conduct throughout this course, the quality of your results will directly reflect your measurement techniques and your ability to follow procedures.

Once we obtain our data, we must analyze it to understand its significance and application to the developed hypothesis and theory. A very important part of the analysis is the error estimate of the data. Without any estimate of error, we have no way to gauge the value or significance of the results. We also cannot compare the results to those obtained during different experiments. Error analysis is just as important as the values and conclusions you achieve during your experiments.

This laboratory will consist of different types and lengths of experiments. Some will be highly structured while others will require some genuine experimentation of your own design. The computer will also be used as a tool for acquiring and analyzing data. The structure of this lab is designed to minimize work outside of the scheduled laboratory period. Ideally, no work on laboratory material should be done outside of the scheduled session, other than some advanced review and reading. This is possible, however, only if you make efficient use of both your time in the lab and the instructor's assistance during the lab period.

In the case of a laboratory absence, contact the instructor, in advance if possible, to arrange for either an alternate section of attendance or to schedule a makeup session. This will be done with a makeup permit and requires you to contact the instructors involved. Your laboratory instructor will explain this process. There will also be allotted time toward the end of the semester for students that need to makeup laboratory work.

Required Competencies

- Basic math and algebra skills as obtained in a college algebra or higher level math class.
- Suffiecient mastery of material completed in Physics 10 or 11 and Physics 12.
- Basic knowledge of the material covered in Physics 13 or Physics 21. This course may be taken concurrently with either course.

- Computer Proficiency.

Final Competencies

- Demonstrate the ability to use the scientific method to test a hypothesis relating to material from introductory electromagnetism, electronics, optics or modern physics.
- Demonstrate the ability to use the computer program CAPSTONE to acquire data.
- Demonstrate how to collect data in a neat and organized fashion.
- Demonstrate proficiency with using Microsoft Excel to create data tables and graphs.
- Demonstrate how to test concepts in introductory electromagnetism, electronics, optics and modern physics using data collected from an experimental set-up.
- Demonstrate a basic understanding of error and how to apply error analysis to experimental results.
- Demonstrate the ability to draw well supported scientific conclusions from the results of experimental data.
- Demonstrate the ability to maintain a coherent laboratory notebook that would allow a freshman physics major to accurately repeat the recorded experiment.

Laboratory Format

The Laboratory Notebook

Your laboratory notebook will be turned in at the end of each lab period. You will choose a partner to work with, and you will work on the experiment together. However, your laboratory notebooks will be completed and individually graded. In other words, while you share in the work of conducting the experiment, the notebooks are a record of your individual work. Remember that your laboratory notebook is a log of your experiment. It is not meant to be a finished report or paper, but it should contain descriptions and explanations of the experiment such that you can go back at a later date and understand the experiment and as well as the results. A reader should be able to reproduce your experimental results using only the information in your notebook. The following items should be included in your laboratory notebook for each experiment:

1) Purpose or Goal: Include a clear objective and intended outcome of the experiment.

2) List of Materials: Include the equipment needed to complete the experiment.

3) Diagram of The Experiment: Include a diagram mapping out the set up of the equipment, allowing a reader to recreate the experimental set-up in the laboratory.

4) Experimental Procedure: Include a detailed procedure of the experiment in your notebook, such that every step of the experiment can be repeated by a reader.

5) Answers to Questions: Include answers to all questions asked of the student in the lab manual for each particular experiment. These questions will be graded by the instructor as part of the notebook grade for each individual experiment.

6) Data: Include any data taken, usually best displayed in a table or chart. This includes any graphs or computer printouts created with the data.

7) Calculations and Analysis: Include any calculations and analysis conducted in the experiment in an orderly fashion. This includes percent error or percent difference calculations that give a predictable range to your data.

8) Results and Conclusion: Include a final summary of the results in your notebook followed by a conclusion. In other words, state if the experiment was successful or not.

9) Error Analysis: Include an error analysis in your notebook, discussing problems with the experiment and possible improvements that could be made.

Your notebook should be clearly legible, neat, and contain all of the relevant information, such as units and equations. Neatness and clarity are two of the most important aspects of your notebook. While you may easily be able to read your own handwriting, someone else who uses your notebook at a later time as a guide may not be able to understand your work if it is not neat and well laid out. Also, any graphs or tables you have in your notebook should be properly labeled and have the correct units. A graph for example, should have the $x-$axis and $y-$axis clearly labeled with the correct units, a title, and a legend.

Special Projects

During the last week of the semester, you will conduct an experiment similar to one of the experiments you performed during the semester. The special project is a form of a test intended to measure your ability to conduct an experiment, understand laboratory and data analysis procedures, and reproduce accurate results. During the special project, you will conduct the experiment by yourself and only be allowed to use your laboratory notebook. Therefore, it is extremely important to keep a very thorough record of your experiments in the notebook. Below is a list of topics that you will be tested on at the end of the semester.

- Measure the period of a standing wave with an oscilloscope.
- Measure the charge to mass ratio of an electron.
- Measure the focal length of a diverging lens.
- Measure the focal length of a converging lens.
- Measure a spectrum using a grating.
- Use a computer to measure capacitance.
- Measure Planck's constant.
- Transistor amplifier.
- Interference and diffraction of light.

- Measure a magnetic field using a computer.
- Electric fields and electric potential.
- Measure voltages and frequencies with an oscilloscope.

Attendance

Attendance is REQUIRED by Lehigh University rules and procedures. If you are absent due to medical reasons, you should obtain an excuse from the Dean of Students. If you are absent due to other conflicts such as athletics, you must contact your lab instructor in advance, as well as obtain an excuse from the Dean of Students. Only then will the instructor work with you in a timely fashion to make up the lab. Failure to follow this protocol for absences will result in a grade of zero for the missed lab.

Classroom protocol

The physics laboratory is a place for learning. Throughout the semester, you will be working with many expensive pieces of equipment. There is to be NO FOOD OR DRINK in the laboratory classroom. Not only could spilled drinks or food ruin the equipment, it could also be very unhealthy for you to use the equipment and then touch or ingest food. If you are caught with food o drink in the lab, you will be asked to leave the laboratory classroom and either dispose of the items or finish with them outside the lab setting.

Preparation

You should read the experiment write up in this manual BEFORE you come to your lab section. Please keep in mind that you will not be doing the labs in exact numerical order. (Schedule will be handed out at the beginning of the semester.) Please follow COLOR matching of electrical leads (red wires to red terminals, black wires to black terminals, etc.).

Grades

A student's grade in the course is determine by the average of the graded lab experiments in the notebooks and the special project grade. Grading of all materials is the responsibility of the lab instructors, with oversight from the professor in charge of the course. The grades for the course may be curved for each section, and the final letter grade may depend on your relative score as compared to the rest of the students in your section. The breakdown of your grade for the lab is as follows:

Laboratory Notebooks

During the course of the semester, the laboratory instructor will collect the laboratory notebooks after each laboratory session. The instructor will go through the notebooks and grade them to make sure the work is being completed correctly. The grading will be based on a rubric encompassing the items previously described that are expected to be included in the laboratory notebook. The rubrics for each experiment will be made available to you by the instructor. Comments may or may not be written in your graded notebook, depending on the quality of your work. The graded laboratory notebooks will be worth 80% of your grade in this course. In assigning this 80%, effort and participation in the class will certainly be considered. Remember, that the purpose of the laboratory notebook is to help the student keep an organized record of the work done in the laboratory. Instructors will look for things including description of the equipment and procedures, accuracy of the results, error analysis, conclusions, neatness, and organization.

Special Projects

The special project grade will be based on the accuracy of your answer as well as the presentation and organization of your work. This will be the complete reproduction of a previous experiment, but with a slight difference or twist. The special project will make up the other 20% of your grade in the course.

Accommodations for Students with Disabilities

If you have a disability for which you are or may be requesting accommodations, please contact both your instructor and the Office of Academic Support Services, Williams Hall, Suite 301 (610-758-4152) as early as possible in the semester. You must have documentation from the Academic Support Services office before accommodations can be granted.

The Principles of Our Equitable Community

Lehigh University endorses The Principles of Our Equitable Community found at the following website:

http://www.lehigh.edu/~inprv/pdfs/active_pdf_forms/PrinciplesEquity_Sheet_v2_032212.pdf

We expect each member of this class to acknowledge and practice these principles. Respect for each other and for differing viewpoints is a vital component of the learning environment inside and outside the classroom.

Religious holidays

1) Inform your instructor that you will be absent from class due to observance of religious holidays.

2) Arrange with the instructor to complete assignments or any required make-up work.

3) Dates for many religious holidays are posted on the Chaplain's web page that follows:

https://chaplain.lehigh.edu/node/6

Student Senate Statement on Academic Integrity

We, the Lehigh University Student Senate, as the standing representative body of all undergraduates, reaffirm the duty and obligation of students to meet and uphold the highest principles and values of personal, moral and ethical conduct. As partners in our educational community, both students and faculty share the responsibility for promoting and helping to ensure an environment of academic integrity. As such, each student is expected to complete all academic course work in accordance to the standards set forth by the faculty and in compliance with the University's Code of Conduct.

Final Comment

Your laboratory instructor is there to help you with the laboratory procedures and understand the material. However, they are NOT there to run the experiment for you, perform your calculations, or draw conclusions from your data. The process of understanding the strengths and weakness of your experiments and relating the results to theory are very important parts of being a successful student or scientist.

Course Outline

Experiment	**Content**	**Expected Outcome**
Experiment 1: Electric Fields and Electric Potential	• Electric Potential • Equipotential Lines • Electric Field • Measuring Potential Difference	• Demonstrate using a digital multimeter to measure voltage at a point • Demonstrate finding and drawing equipotential lines. • Demonstrate drawing the electric field using the equipotential lines. • Demonstarting how to calculate the magnitude of the electric field between two equipotential lines.
Experiment 2: Resistors in Series and Parallel	• Resistance • Ohm's Law • Using Microsoft Excel • Graphing techniques • Trendlines with Microsoft Excel • Resistors in Series • Resistors in Parallel	• Demonstrate ability to construct a simple circuit using a resistor. • Demonstrate using a Curent vs. Voltage graph to obtain the resistance of a resistor. •Demonstrate how to construct circuits with resistors in series or parallel • Demonstrate how to measure the total resistance of various circuits. • Demonstrate how to calculate the total resistance of various combinations of resistors.
Experiment 3: The Discharge of a Capacitor (3A) and How to Use an Oscilloscope (3B)	• Data aquisition with CAPSTONE • Capacitance • RC circuits • Capacitors in series • Capacitors in parallel • Using an oscilloscope • AC circuits	• Demonstrate using CAPSTONE to obtain RC Voltage vs. time for discharge. • Demonstrate the ability to construct circuits with capacitors in series or parallel • Demonstrate how to determine the capacitance from the discharge of • Demonstrate how to use an oscilloscope to measure voltages in an DC or AC circuit. • Demonstrate how to use an oscilloscope to determine the frequency or period of an input signal.
Experiment 4: AC Circuits in Steady State	• AC Circuits • Inductors • RCL Circuits • Impedance • Current and Voltage Phases	• Demonstrate how construct an RCL circuit in series and parallel combinations. • Demonstrate how to measure voltage and current using an oscilloscope. • Demonstrate how to calculate impedance of RCL circuit elements. • Demonstrate how to determine phase difference between voltage and current signals.

Experiment	Content	Expected Outcome
Experiment 5: Amplifiers	• Amplifiers • Amplification • Emitter resistors • Logarithmic graphs	• Demonstrate how to construct an amplifier circuit with various emitter resistors. • Demosntrate how to use the oscilloscope to measure amplification of a signal. • Demonstrate how to predict amplification using emitter resistor values. • Demonstrate how to create a plot with a logrithmic scale. • Demonstrate how to determine the limits of the amplifier.
Experiment 6: Converging Thin Lens	• Converging Lens • Thin lens equation • Focal length • Object and image sizes	• Demonstrate how project an image of an object with a converging lens. • Demonstrate how to experimentally determine the relationship between object and image distances. • Demonstrate how to experimentally determine the relationship between object and image sizes. • Demonstrate how to determine the focal local graphically using image and object distances. • Demonstrate how to determine the focal length using the auto-collimation method. • Demonstrate how to determine the focal length using an object at infinity.
Experiment 7: Converging Mirrors and Two-Lens Systems	• Converging mirror • Diverging Lens • Virtual image • Refractor telescope	• Demonstrate how to project an image of an object with a converging mirror. • Demonstrate how to experimentally determine the focal length of a converging mirror. • Demonstrate how to project the virtual image of an object with a diverging lens • Demonstrate how to view the virtual image from a diverging lens using a converging lens. • Demonstrate how to determine the focal length of a diverging lens with a converging lens. • Demonstrate how to construct a refractor telescope using two converging lenses.
Experiment 8: Waves	• Faraday effect • Wave pulses on a wire • Standing waves • Harmonics • Frequency and period	• Demonstrate how to use CAPSTONE and a magnet to produce images of waves on a wire. •Demonstrate how to generate a simple wave-pulse on a wire. • Demonstrate how to determine the travel time of a wave-pulse through a wire. • Demonstrate how to determine the speed of a wave-pulse in a wire. • Demonstrate how to generate harmonics of standing waves in a wire. • Demonstrate how to determine the frequency and the period of standing waves in a wire.

Experiment	Content	Expected Outcome
Experiment 9: Measuring the Mass of an Electron	• Mass of an electron • Charge of an electron • Magnetic field • Magnetic induction • Helmholtz Coils • Electrons in a magnetic field	• Demonstrate how to use CAPSTONE to determine the magnetic field induced in secondary coils of wire. • Demonstrate knowledge of using Helmholtz coils to produce a magnetic field. • Demonstrate an understanding of how a vacuum tube produces an electron beam. • Demonstrate how to use a magnetic field to bend a beam of electrons. • Demonstrate how to alter a magnetic field and use it to change the radius of curvature of an electron beam in the field. • Demonstrate how to experimentally determine the mass of an electron using a magnetic field and the radius of curvature of an electron beam in the field.
Experiment 10: Measuring the Index of Refraction of Glass Using a Spectrometer	• Using a spectrometer • Vernier scale • Spectral bands • Refraction • Dispersion in a prism • Prism in a spectrometer • Deviation angle in a prism • Index of Refraction	• Demonstrate how to use a spectrometer to identify spectral bands from a light source. • Demonstrate proficiency at reading the angular Vernier scale. • Demonstrate how to adjust the prism in a spectrometer to find spectral lines. • Demonstrate how to identify the deviation angle of light exiting a prism. • Demonstrate how to determine the index of refraction of the prism glass using the deviation angle of spectral lines.
Experiment 11: Measuring Hydrogen Spectra Using a Diffraction Grating	• Balmer series • Diffraction grating • Spectrometer • Vernier scale • Wavelength • Spectrum of Hydrogen	• Demonstrate how to calculate the wavelengths of light in the Balmer series • Demonstrate how to calculate the distance between lines in a diffraction grating. • Demonstrate how to identify the deviation angle of light passing through a diffraction grating. • Demonstrate how to determine the wavelength of a spectral line using the deviation angle. • Demonstrate how to determine if an element is part of the Balmer series.
Experiment 12: Photoelectric Effect	• Using photocells • Photoelectric effect • Threshold voltage • Planck's constant	• Demonstrate how to produce current in a photocell with a light source. • Demonstrate how to create a circuit opposing the current produced by the photocell. • Demonstrate how to use an oscilloscope to measure the threshold voltage. • Demonstrate how to restrict the wavelength of light from a source. • Demonstrate how to determine Planck's constant from a graph of threshold voltage vs. frequency of light.

Experiment	Content	Expected Outcome
Experiment 13: Interference and Diffraction of Coherent Light	• LASERs • Wave interference • Double-slit interference • Single-slit diffraction	• Demonstrate how to safely use a LASER. • Demonstrate how to produce a double-slit pattern using a LASER. • Demonstrate how to determine the distance between constructive maxima in a double-slit pattern. • Demonstrate how to determine the wavelength light using the double-slit interference pattern. • Demonstrate how to produce a diffraction pattern using a LASER and a diffraction grating. • Demonstrate how to determine the distance between constructive maxima in a diffraction pattern. • Demonstrate how to determine the wavelength of light using the diffraction pattern.