Physics 12
Introductory Physics Lab I

Fall 2018

Welcome to Physics 12. 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 220 or LL 218

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 12 lab manual (available at the bookstore):
   Physics 012 - Introductory Physics Lab I - Laboratory Instruction Manual.
2) The assigned laboratory notebook from the bookstore (#77648 or equivalent sewn binding).
3) Scientific calculator.
4) Metric ruler.

Contents

Physics 12 , "Introductory Physics I Laboratory" is the one-credit laboratory portion of the first semester of Lehigh University's two-semester introductory physics sequence. In Physics 12, we cover the following broad subject areas, mechanics, waves, and thermodynamics. Specific experiments include working with topics such as free fall motion, forces, centripetal motion, friction, momentum, energy, colliding objects, rotational systems, a pendulum, and the specific heat of water.

Prerequisites/Corequisites

Physics 12 requires prior credit or simultaneous enrollment in an accompanying lecture course for first semester introductory physics, Physics 10 or Physics 11.

Relationship of This Lab to Physics 10 and 11

It is impractical and unnecessary to arrange that each experiment be done in the same week as the related material is studied in Physics 10 or 11. In most cases you will encounter each new physics principle in the lecture first, but not always. 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 either class. However, most of the experiments are designed to introduce you to the equipment that is used to measure mechanical 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 degree of accuracy as possible. 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 gage 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 experiments of differing types and lengths. 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 also of the instructor's assistance during the lab period.

In the case of a laboratory absence, contact me, in advance if possible, to arrange for either an alternate time to schedule makeup work. There will also be alloted time toward the end of the semester for students that need to makeup work.

Required Competencies

- Basic math and algebra skills as obtained in a college algebra or higher level math class.
- Basic knowledge of the material covered in Physics 10 or Physics 11. 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 mechanics or thermodynamics.
- 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 mechanics and thermodynamics 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.

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

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

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

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

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

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

g) Calculations and Analysis: Include any calculations and analysis conducted in the experiment in your notebook in an orderly fashion. This includes percent error calculations, giving a predictable range to your data.

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

i) 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 its 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.

Quizzes

A short quiz will be given in class some weeks, based on lab work you have already completed. The quiz will require you to reproduce a small aspect of the experiment, testing what you learned from the current or previous week's exercises. The quiz should take no more than 10 minutes, and will be graded on the accuracy of your results.

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 will 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 acceleration due to gravity of a falling object.
- Measure the speed of a sound wave.
- Measure the period of a pendulum.
- Measure the specific heat of a liquid.
- Measure the coefficients of static and kinetic friction .
- Determine the initial speed of a launched projectile.
- Measure the moment of inertia of a rotating object.
- Measure the angular acceleration of a rotating object.
- Determine if a collision between two objects is elastic or inelastic.

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.)

Grades

A student's grade in the course is determine by the average of the graded lab experiments in the notebooks, the average quiz grade, 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 60% of your grade in this course. In assigning this 60%, 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.

Quizzes

The quizzes will be graded on the accuracy of your results. The closer your solution is to the actual answer, the higher your grade. These quizzes will be averaged together and make up 20% of your grade in the course.

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 scientist or student.

Course Outline

Experiment 1: Measurement and Error Analysis	• Measurement techniques • Measurement error • Significant figures • Min/Max error analysis	• Demonstrate correct measurement of physical properties • Demonstrate correct use of significant figures • Demonstrate proper use of measurement error • Demonstrate use of Min/Max error analysis
Experiment 2: The Falling Body	• Working with Microsoft Excel • Graphing techniques • Physics of a falling object • Trendlines with Microsoft Excel • The method of least squares • Percent error	• Demonstrate proficiency of using Microsoft Excel for data tables, graphing, and least squares • Demonstrate the ability to obtain gravitational acceleration with error from position versus time data of a falling object • Demonstrate how to calculate percent error
Experiment 3: Projectile Motion	• Data acquisition with CAPSTONE • Algebraic techniques • Physics of a projectile • Measurement techniques • Percent difference	• Demonstrate proficiency of using CAPSTONE for collection of velocity data • Demonstrate the ability to obtain position data from a launched projectile and make predictions of position in future launches at different angles. • Demonstrate how to calculate percent difference.
Experiment 4: Balance of Forces	• Weight force • Equilibrium of forces • Addition of force vectors	• Demonstrate how to place three weight forces in static equilibrium using a force balance table • Demonstrate the ability to properly add two-dimensional force vectors
Experiment 5: Centripetal Acceleration	• Data acquisition with CAPSTONE • Angular velocity • Rotational motion • Centripetal acceleration • Centripetal force	• Demonstrate how to use CAPSTONE with a force sensor to acquire the centripetal force as a function angular velocity • Demonstrate an understanding of how the centripetal force, angular velocity, mass, and radial length are all related

Experiment 6: Friction	• Static Friction • Kinetic Friction • Uniform motion up an incline	• Demonstrate how to measure an angle of incline • Demonstrate how to use CAPSTONE to measure and graph the tension force of an object as a function of time as it's pulled up an incline at constant velocity • Demonstrate how to determine the coefficient of static friction from the graph of tension • Demonstrate how to determine the coefficient of kinetic friction from the graph of tension • Demonstrate an understanding of the difference between static and kinetic friction • Demonstrate an understanding of the effects of mass on the coefficients of friction
Experiment 7: Collsions and Conservation Laws	• Velocity • Impulse • Momentum • Conservation of Momentum • Kinetic Energy • Conservation of Energy	• Demonstrate how to use CAPSTONE to measure the velocity of a moving a cart with a photogate. • Demonstrate how to determine the momentum of a moving cart. • Demonstrate how to determine the impulse of a moving cart. • Demonstrate how to determine the kinetic energy of a moving cart. • Demonstrate how to determine if momentum is conserved. • Demonstrate how to determine if energy is conserved. • Determine how to classify different types of collisions.
Experiment 8: Rotational Dynamics I	• Torque • Angular Acceleration • Moment of Inertia	• Demonstrate how to use CAPSTONE to measure the angular velocity of a rotating object. • Demonstrate how change the torque on a rotating object using the tension created through a string attached to a hanging mass m that falls and accelerates. • Demonstrate how to determine the moment moment of inertia of an object from a graph of $a/g - a$ vs. m. • Demonstrate how to calculate the moment of inertia for a rotating beam using its mass and its length. • Demonstrate how to calculate the moment of inertia for a block rotating about an axis axis using its mass and its distance from the axis.

Experiment	Content	Expected Outcome
Experiment 9: Rotational Dynamics II	• Torque • Angular Acceleration • Moment of Inertia • Angular Momentum • Conservation of Angular Momentum	• Demonstrate how to use CAPSTONE to measure the angular velocity of a rotating object. • Demonstrate how change the torque on a rotating object using the tension created through a string attached to a hanging mass m that falls and accelerates. • Demonstrate how to determine the moment of inertia of an object from a graph of $a/g - a$ vs. m. • Demonstrate how to calculate the moment of inertia for a rotating disk using its mass and its radius. • Demonstrate how to calculate the moment of inertia for a rotating disk and ring using their masses and radii. • Demonstrate how to determine the angular momentum of an object. • Demonstrate how to determine if the angular momentum is conserved.
Experiment 10: Motion of a Simple Pendulum	• Smple Pendulm Motion • Small Angle Approximation • Period of a Simple Pendulum • Truncated Series Approximation	• Demonstrate how to use CAPSTONE to measure the period of a pendulum. • Demonstrate how to apply the small angle approximation to the differential equation of a pendulum. • Demonstrate how to produce a graph of the period as a function of maximum release angle. • Demonstrate the theoretical period of the pendulum using the small angle approximation. • Demonstrate the theoretical period of the pendulum using the truncated series approximation. • Demonstrate how to produce a graphical comparison between the measured and calculated values of the period of the pendulum.

Experiment	Content	Expected Outcome
Experiment 11: Speed of Sound	• Oscilloscope • Wave Oscillations • Wavelength and Wavelength Error • Wave Speed • Counting Method for Wavelength • Theoretical Speed of Sound	• Demonstrate how to use the oscilloscope to measure the distance it takes for sound to travel a set number of oscillations. • Demonstrate how to use an oscilloscope to determine the wavelength of a wave. • Demonstrate how to calculate the wavelength of a sound wave with error using the counting method. • Demonstrate how to determine the speed of of a sound wave from the wavelength. • Demonstrate how to theoretically determine the speed of sound in air, using an ideal gas approzimation.
Experiment 12: Specific Heat	• Temperature Measurement • Ambient Heat Loss • Heat Related to Temperature • Specific Heat	• Demonstrate the ability to use CAPSTONE and a PASCO calrimotry and thermometer apparatus to measure the temperature of water as its temperature changes. • Demonstrate the ability to obtain the slope of the graph of temperature as a function of time. • Demonstrate the ability to determine the change in temperature over time due to the addition of heat during a heating process. • Demonstrate the ability to determine the change in temperature over time due to the loss of heat to the surroundings. • Demonstrate the ability to determine the specific heat of a liquid with error not considering heat lost to the surroundings. • Demonstrate the ability to determine the specific heat of a liquid with error when considering heat lost to the surroundings.