# Physics 12
# Introductory Physics Lab I

## Spring 2017

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 your teaching assistant as soon as possible.

**Class Times:** Three hours once a week
**Location:** LL 220 or LL 218

**Contact Information**


| | |
|---|---|
| Head Instructor: | Volkmar Dierolf |
| Office: | LL 214 |
| Office Phone: | 610-758-3915 |
| Email: | vod2@lehigh.edu |


**Text**
*Physics 012 - Introductory Physics Laboratory I Instruction Manual*

**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 the instructor, in advance if possible, to arrange for either an alternate section of attendance or 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 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 your 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 your results. A reader should be able to reproduce your experimental results using only the information in your notebook. The following items should be included for each experiment in your laboratory notebook:

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 $x-$ and $y-$axis clearly labeled with the correct units, a title, and a legend.

**Quizzes**
A short quiz will be given some weeks at the end of class when you have competed your lab work. The quiz will require you to reproduce a small aspect of the experiment, testing what you learned from the current 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 only be allowed to use your laboratory notebook in completing the project. Therefore, it is extremely important to keep a very through record of your experiments in your notebook.

**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 DRINKS in the laboratory classroom. Not only could spilled drinks or food ruin the equipment, it could be very unhealthy 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 classroom and either dispose of the items or finish with them outside the lab setting.

**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, rand 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 your 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 the 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 solely 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.

**Students with Disabilities**
if you have a disability for which you are or may be requesting accommodations, please contact both your laboratory instructor and the Office of Academic Support Services located at Williams Hall in Suite 301 as early as possible in the semester at 610-758-4152. You must have documentation form the Office of Academic Support Services before accommodations will 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/initiatives/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.

**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 | Content | Expected Outcome |
|---|---|---|
| Experiment 1:<br>Measurement and<br>Error Analysis | • Measurement techniques<br>• Measurement error<br>• Significant figures<br>• Min/Max error analysis | • Demonstrate correct measurement of physical properties<br>• Demonstrate correct use of significant figures<br>• Demonstrate proper use of measurement error<br>• Demonstrate use of Min/Max error analysis |
| Experiment 2:<br>The Falling Body | • Working with Microsoft Excel<br>• Graphing techniques<br>• Physics of a falling object<br>• Trendlines with Microsoft Excel<br>• The method of least squares<br>• Percent error | • Demonstrate proficiency of using Microsoft Excel for data tables, graphing, and least squares<br>• Demonstrate the ability to obtain gravitational acceleration with error from position versus time data of a falling object<br>• Demonstrate how to calculate percent error |
| Experiment 3:<br>Centripetal Acceleration | • Data acquisition with CAPSTONE<br>• Angular velocity<br>• Rotational motion<br>• Centripetal acceleration<br>• Centripetal force | • Demonstrate how to use CAPSTONE with a force sensor to acquire the centripetal force as a function angular velocity<br>• Demonstrate an understanding of how the centripetal force, angular velocity, mass, and radial length are all related |
| Experiment 4:<br>Balance of Forces | • Weight force<br>• Equilibrium of forces<br>• Addition of force vectors | • Demonstrate how to place three weight forces in static equilibrium using a force balance table<br>• Demonstrate the ability to properly add two-dimensional force vectors |
| Experiment 5:<br>Friction | • Static Friction<br>• Kinetic Friction<br>• Acceleration down an incline | • Demonstrate how to measure an angle of incline<br>• Demonstrate how to find the value of the coefficient of static friction from the angle of incline<br>• Demonstrate how to use CAPSTONE to record the velocity and determine the acceleration of an object moving down an incline<br>• Demonstrate how to determine the coefficient of kinetic friction using the acceleration of an object down an incline with a known slope.<br>• Demonstrate an understanding of the difference between static and kinetic friction |

| | | |
|---|---|---|
| Experiment 6: Collsions and Conservation Laws | • Velocity<br>• Impulse<br>• Momentum<br>• Conservation of Momentum<br>• Kinetic Energy<br>• Conservation of Energy | • Demonstrate how to use CAPSTONE to measure the velocity of a moving a cart with a a photogate.<br>• Demonstrate how to determine the momentum of a moving cart.<br>• Demonstrate how to determine the impulse of a moving cart.<br>• Demonstrate how to determine the kinetic energy of a moving cart.<br>• Demonstrate how to determine if momentum is conserved.<br>• Demonstrate how to determine if energy is conserved.<br>• Determine how to classify different types of collisions. |
| Experiment 7: Rotational Dynamics | • Torque<br>• Angular Acceleration<br>• Moment of Inertia<br>• Angular Momentum<br>• Conservation of Angular Momentum | • Demonstrate how to use CAPSTONE to measure the angular velocity of a rotating object.<br>• Demonstrate the relationship between the acceleration of a falling body and the mass of the body.<br>• Demonstrate how to determine the moment of inertia of an object from a graph of $a/g - a$ vs. $m$.<br>• Demonstrate how to calculate the moment of inertia for different objects using their mass and physical dimensions.<br>• Demonstrate how to determine the angular momentum of an object.<br>• Demonstrate how to determine if the angular momentum is conserved. |
| Experiment 8: Motion of a Simple Pendulum | • Smple Pendulm Motion<br>• Small Angle Approximation<br>• Period of a Simple Pendulum<br>• Truncated Series Approximation | • Demonstrate how to use CAPSTONE to measure the period of a pendulum.<br>• Demonstrate how to apply the small angle approximation to differential equation of a pendulum.<br>• Demonstrate how to produce a graph of the period as a function of maximum release angle.<br>• Demonstrate the theoretical period of the pendulum using the small angle approximation.<br>• Demonstrate the theoretical period of the pendulum using the truncated series approximation.<br>• Demonstrate how to produce a graphical comparison between the measured and calculated values of the period of the pendulum. |

| | | |
|---|---|---|
| Experiment 9: Speed of Sound | • Oscilloscope<br>• Wave Oscillations<br>• Wavelength and Wavelength Error<br>• Wave Speed<br>• Counting Method for Wavelength<br>• 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.<br>• Demonstrate how to use an oscilloscope to determine the wavelength of a wave.<br>• Demonstrate how to calculate the wavelength of a sound wave with error using the counting method.<br>• Demonstrate how to determine the speed of a sound wave from the wavelength.<br>• Demonstrate how to theoretically determine the speed of sound in air, using an ideal gas approzimation. |
| Experiment 10: Specific Heat | • Temperature Measurement<br>• Ambient Heat Loss<br>• Heat Related to Temperature<br>• 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.<br>• Demonstrate the ability to obtain the slope of the graph of temperature as a function of time.<br>• Demonstrate the ability to determine the change in temperature over time due to the addition of heat during a heating process.<br>• Demonstrate the ability to determine the change in temperature over time due to the loss of heat to the surroundings.<br>• Demonstrate the ability to experimentally determine the specific heat of a liquid with error not considering the loss of heat to the surroundings.<br>• Demonstrate the ability to experimentally determine the specific heat of a liquid with error when considering the loss of heat to the surroundings. |

# Experiment Schedule for Physics 012
# Spring 2017

| **Dates** | **Sections:**<br>**061, 064, 067, 069, 070** | **Sections:**<br>**062, 068, 071, 073** |
|---|---|---|
| Week 1<br>Jan. 23 - Jan. 27 | Experiment 1<br>Measurement and<br>Error Analysis | Experiment 1<br>Measurement and<br>Error Analysis |
| Week 2<br>Jan. 30 - Feb. 3 | Experiment 2<br>The Falling Body | Experiment 2<br>The Falling Body |
| Week 3<br>Feb. 6 - Feb. 10 | Experiment 4<br>Balance of Forces | Experiment 3<br>Centripetal Acceleration |
| Week 4<br>Feb. 13 - Feb. 17 | Experiment 3<br>Centripetal Acceleration | Experiment 4<br>Balance of Forces |
| Week 5<br>Feb. 20 - Feb. 24 | Experiment 5<br>Friction | Experiment 5<br>Friction |
| Week 6<br>Feb. 27 - Mar. 3 | Experiment 6<br>Collisions and<br>Conservation Laws | Experiment 6<br>Collisions and<br>Conservation Laws |
| Week 7<br>Mar. 6 - Mar. 10 | Experiment 6 Continued<br>Collisions<br>Conservation Laws | Experiment 6 Continued<br>Collisions<br>Conservation Laws |
| Week 8<br>Mar. 20 - Mar. 24 | Experiment 7<br>Rotational Dynamics | No Lab |
| Week 9<br>Mar. 27 - Mar. 31 | Experiment 7<br>Rotational Dynamics Continued | Experiment 8<br>Pendulum |
| Week 10<br>Apr. 3 - Apr. 7 | Experiment 8<br>Simple Pendulum | Experiment 7<br>Rotational Dynamics |
| Week 11<br>Apr. 10 - Apr. 14 | No Lab | Experiment 7<br>Rotational Dynamics Continued |
| Week 12<br>Apr. 17 - Apr. 21 | Experiment 9<br>Speed of Sound | Experiment 9<br>Speed of Sound |
| Week 13<br>Apr.24 - Apr. 28 | Experiment 10<br>Specific Heat | Experiment 10<br>Specific Heat |
| Week 14<br>May 1 - May 5 | Special Projects | Special Projects |