Physics 12
Introductory Physics Lab I

Spring 2022

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 session. Because this is an experimental lab course with some online components, I expect that there may be certain problems or issues that may surface with the technology. You will need to contact me immediately if any problems that occur. 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 222 with pre-lab instruction, taking of data, and analyzing results. Lab reports will be submitted as a Word document though CourseSite.

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) Access to the internet.

2) A Lehigh University email account, giving you access to CourseSite.

3) Access to Microsoft Office or the Apple Equivalent, specifically for use of Word and Excel.

4) Scientific calculator.

Text: All instructions and procedures will be provided online through CourseSite.

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/Co-requisites

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 report 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 or computer simulations that are 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 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 allow experimental work with data and analysis to be completed during the normal scheduled laboratory period. Ideally, no work on data analysis will be done outside of a scheduled session. Once the data is taken and analyzed within the lab period, students will have 24 hours to work within their own time constraints to complete a lab report and turn it in through CourseSite. This is possible, however, only if you make efficient use of both your time and the instructor's assistance when needed.

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 at the discretion of the instructor. Your laboratory instructor will explain the process required for their individual lab section.

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 set-up certain pieces of lab equipment for the process of taking data.
- 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 create a coherent laboratory report that would allow a freshman physics major to accurately repeat the recorded experiment.

Course Structure

Due to the Covid 19 pandemic, this course will be offered with certain online components. The first week, the lab will be done virtually online. Your lab instructor will contact you to give you details on how this first lab will be conducted via ZOOM. Though you will be attending lab face-to-face for the following weeks to acquire and analyze data for the lab experiments, we will be using the CourseSite interface for sharing all lab procedures and submitting all lab reports. CourseSite will also be used for sharing all grades, solutions, and rubrics with students in the class. As with any remote computer processes, there may indeed be some bugs, but we will work things out as they happen to ensure you receive a great learning experience this semester. Here are the steps that we will be following for the course.

1) You do not need to purchase a laboratory manual. Lab procedures will be provided to you by your laboratory instructor through CourseSite. For all the experiments this semester, you will be taking and analyzing the data yourselves in the laboratory. The lab procedures document is what you will use and follow to take your data, analyze your data, and complete your report. In other words, the procedures outline the steps necessary to analyze and complete each experiment.

2) AS IT STANDS NOW, ALL LABS BUT THE FIRST WILL BE COMPLETED VIA A FACE-TO-FACE METHOD OF INSTRUCTION. Due to the Covid 19 pandemic, it is possible that at some point, we may be forced to move to an online delivery of instruction. In the event that we are forced to move courses online, information will be provided to you about how to proceed by your lab instructor. There are lab experiments using simulations that have been prepared for you in the event that this happens. Lab will continue to proceed, even if we are forced online. However, we expect for now, that all experiments will require face-to-face work in the laboratory.

3) When attending lab, it will be your responsibility to read the lab procedures ahead of time, BEFORE coming to class. The lab instructor will begin each lab session with a pre-lab lecture, discussing concepts and details that you will need to successfully complete each experiment. AFter the pre-lab lecture, your lab instructor will be available during the class to give you assistance in taking or analyzing your data if necessary.

4) When entering the classroom for the lab, you must wear a mask at all times. Gloves will be provided to you at each lab station for those interested in using them. You will need to clean your lab station with the materials provided BEFORE using the equipment. If possible, cleaning your lab station before class is preferable . Once you have cleaned your station thoroughly, you can begin taking data after the pre-lab lecture.

5) Once you have finished taking and analyzing data, it will be your responsibility to return the lab station to the condition in which you found it. You will then be responsible for cleaning your lab station one more time before you leave. Once the station has been sanitized, and you have properly obtained your data and results, you may leave the lab and return to your dorms or homes to finish your lab reports. These reports will be submitted electronically through CourseSite.

6) An Excel document template will be provided to you through CourseSite as necessary for each experiment. You will be responsible for taking recording the necessary data in the Excel document and analyzing it. Not every experiment will NEED an Excel document, but feel free to use one for any experiment if it helps you organize your work.

7) A lab report template will be provided to you as a document in WORD for you to use when completing your lab reports. It will have instructions and guidance for you, so that when writing up your report, you will know exactly what you are expected to include and how to complete it. This template will be provided to you through CourseSite as well.

8) You will be given 24 hours from the beginning of your lab period to complete your lab reports and submit them electronically through CourseSite. Your reports are to be submitted as a WORD or PDF document. Other document forms will not be accepted or graded.

9) Your reports will be returned to you electronically by your lab instructor through the CourseSite. Grades, solutions, and grading rubrics will also be available on CourseSite after the lab reports are graded and returned to you.

10) There will be a lab practical called “Special Projects” which will be conducted at the end of the course. This delivery process of these special projects will be explained to you by the lab instructor a week or or so before they are conducted.

Laboratory Format

The Lab Report

A lab report will be turned in within 24 hours of each lab session. Your lab reports will be completed, electronically submitted, and individually graded. These reports are a record of your individual work for

each lab session, essentially 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 lab report. The following items are examples of what may be included in your lab report for each experiment. There will be a lab report template that will clearly state what needs to be included in your report 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 if necessary, 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 lab report, 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 procedures for that particular experiment. These questions will be graded by the instructor as part of your lab report grade for each individual experiment.

f) Data: Include any data taken in your report, 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 report 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 report followed by a conclusion. In other words, state if the experiment was successful or not.

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

Your lab report 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 report. While you may easily be able to read your own handwriting or understand your own writing style, someone else who uses your lab report at a later time as a guide may not be able to understand your work if its not neat and well constructed. Also, any graphs or tables you have in your report 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 essentially a lab practical 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 with the assistance of any lab materials provided to you during the course. This includes the use of your lab reports, which is why it is extremely important to keep a very thorough record of your experiment in each report. Below is a list of topics that you will be tested on at the end of the semester.

- Determine the acceleration due to gravity of a falling object.
- Determine the speed of a sound wave.

- Determine the period of a pendulum.
- Determine the specific heat of a liquid.
- Determine the coefficients of static and kinetic friction .
- Determine the initial speed of a launched projectile.
- Determine the moment of inertia of a rotating object.
- Determine 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 or 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

The lab procedures for each experiment will be released weekly at a time determined by the lab instructor. You MUST read these procedures thoroughly BEFORE coming to the lab to take data or contacting the lab instructor with any problems or concerns.

Grades

A student's grade in the course is determine by the average of the graded lab reports. 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:

Lab Reports

During the course of the semester, the laboratory instructor will grade your submitted lab reports after each laboratory session. The instructor will go through the reports 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 lab report. The rubrics for each experiment will be made available to you by the instructor. Comments may or may not be written in your graded lab report, depending on the quality of your work. The graded lab reports 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 lab report 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

Lehigh University is committed to maintaining an equitable and inclusive community and welcomes students with disabilities into all of the University's educational programs. In order to receive consideration for reasonable accommodations, a student with a disability must contact Disability Support Services (DSS), provide documentation, and participate in an interactive review process. If the documentation supports a request for reasonable accommodations, DSS will provide students with a Letter of Accommodations. Students who are approved for accommodations at Lehigh should share this letter and discuss their accommodations and learning needs with instructors as early in the semester as possible. For more information or to request services, please contact Disability Support Services in person in Williams Hall, Suite 301, via phone at 610-758-4152, via email at indss@lehigh.edu. For more information, I encourage you to visit the website given by the link included below:

Disability Support Services

The Principles of Our Equitable Community

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

The Principles of Our Equitable Community

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, even when the class is delivered online.

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 perform 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 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: The Atwood Machine	• Data acquisition with CAPSTONE • Velocity • Falling motion • Acceleration • Force	• Demonstrate how to use CAPSTONE with a photogate to acquire the acceleration using a graph of velocity as a function of time. • Demonstrate an understanding of how gravitational acceleration with Newton's Laws applied to the Atwood Machine.

Experiment 6: Friction	• Static Friction • Kinetic Friction • Uniform motion along a flat surface	• Demonstrate how to use CAPSTONE to measure and graph the tension force of an object as a function of time as it's pulled at a 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.