PHYS 130 – Elementary Physics Laboratory I

Lab Location: PSU, Yates Hall, Room 324
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This course is also intended for partial fulfillment of the Pitt State Pathway Curriculum.

Pitt State Pathway Mission Statement: The *Pitt State Pathway* curriculum serves as the heart of the university education by fostering interdisciplinary competencies that typify the educated person. It is designed to facilitate the development of key proficiencies including communication and information literacy. The *Pitt State Pathway* curriculum provides a transformational experience that challenges students to think creatively and critically, and to immerse themselves in the productive examination of humans in their global setting. By encouraging the development of skills that promote life-long learning, the *Pitt State Pathway* fosters a sense of personal responsibility, an appreciation of diversity, and an understanding of interconnectedness in our truly global society.

Essential Study to be covered in this course: Natural World within a Global Context
Biological, physical, and chemical systems form the context for life. Students need to understand how these systems work, how these change naturally, and how these can change as a result of human activities. The implications of these changes are essential for long-term decision-making. In this course we will:

Analyze physical and chemical systems;

Evaluate the implications of changes that result from interactions between natural and human systems.

Companion Element to be covered in this course: Scientific Inquiry
The scientific method is the systematic approach to understanding the world around us. Through experimentation and hypothesis testing, students will apply analytical skills and appropriate methods of scientific inquiry (i.e. qualitative and quantitative) to solve a variety of research questions. In this course we will:
Compose appropriate research questions and hypothesis, drawing from experts, reliable sources, or previously collected data.
Collect, synthesize, and analyze data from multiple sources;
Draw logical conclusions, assessing for gaps and weaknesses, and addressing potential consequences and implications
Communicate results using appropriate delivery methods or formats.

The **Learning Outcome** for Natural World in a Global Context is:

Students will explore global systems conscientiously.

The **Learning Outcome** for Scientific Inquiry is:

Students will analyze data logically.

Course Description: 1 credit. Experiments in mechanics heat sound, kinematics, statics, dynamics, thermodynamics, and rotary/wave motion. Concurrent enrollment required in PHYS 100 College Physics I or PHYS 104 Engineering Physics I. Elementary Physics Lab accompanies the first semester of introductory physics. The laboratory experiments that you will perform will help you learn the subject matter deeper and develop your skills on scientific experimentation. In addition to reinforcing the material covered in lecture class, you will also have a chance to discover new knowledge.

Prerequisite: MATH 113 College Algebra or MATH 110 College Algebra with Review, or MATH 126 Pre-Calculus or MATH 150 Calculus I.

Course Objectives:

Natural World within the Global Context: Level of Student Learning = Milestone II
Analyzes physical and chemical processes and how human activities alter them

Scientific Inquiry: Level of Student Learning = Milestone II
Student will apply the scientific methods to a problem. Student will compare tools of analysis and communicate results

Upon completion of the course, you should be able to:

1. Analyze collected data by graphing and/or using basic mathematical reasoning.

2. Interpret physical information in several forms, including verbal, mathematical, and graphical and use basic mathematical reasoning.

3. Analyze of a particular physical phenomenon or problem using an idealized model, simplifying assumptions where necessary, and relevant limitations.

4. Employ Newton's laws to solve algebra-based kinematics, statics, and translational dynamics problems.

5. Evaluate conservation of energy and momentum in both linear and rotational dynamics problems.

6. Interpret laws of thermodynamics to solve problems involving thermal equilibrium, heat transfer, heat engines and refrigerators.

Methods of Assessment:
Students, on quizzes, lab reports, and exam(s), will *describe, explain and analyze,* items, principles, and processes related to the student outcomes. (Milestone II)

Course Delivery: We will have one lab session every week. Each student is advised to read the lab manual thoroughly before the lab. The instructor will spend about 5 to 10 minutes to introduce the lab. Lab sessions will be used mainly to understand the various equipment used, collect data, and perform analysis on data collected. During the lab, students will work in groups of 3 or 4. It is encouraged that as a group, you discuss among yourself the details of the lab, and make sure you understand the physical principles involved before performing the experiment. Each student must work independently to produce an individual lab report.

Lab Report Submission: Lab reports will be due at the end of each lab session.

REPORTS (*see page 4 for sample lab report sheet)

Title: A title and the names of your lab partners must be included on each report.

Keywords: Three or Four keywords that capture the purpose of lab.

Objective: State what you want to achieve in this experiment. A formal way to do this is to state a question or hypothesis that you want to address. This should be the scientific goal of the experiment. One or two well-thought out sentences is all that you should need for this.

Procedure: A description of the equipment used for the experiment followed by detailed steps used for collecting data. This is like the recipe of the lab. You should include a summary of the lab procedure *in your words*; do not merely copy what is in the manual. This section should demonstrate your understanding of exactly what you measured, how you measured it, and why this measurement helps you answer the question you posed in the objective section. You don't need to detail each step of math that you will do in the analysis, just what your general approach will be for getting your raw data to answer the question you are interested in. This section should not be more than about half a page and should be written is past tense.

Data and Analysis: This section will usually be a list of numbers, organized into a table, that were recorded during the experiment. Always include a title for the table as well as **units**, where appropriate. A number is meaningless in physics unless the dimensions (centimeters or seconds, for example) are also stated. You may place units at the top of a table.
In several of the experiments you will be required to make graphs that illustrate some feature of the data. A graph should always include a title, labels on both the x and y axes, and numbers on each individual axis. When numbering the axis use only "common" numbers (1, 2, 3, 4, or 0, 5, 10, 15), not (3, 7, 11, 15). You will need to examine your data and draw conclusions from the tables and graphs you made. If there are questions in your lab handout, answer these questions in paragraph form. In any case, you will be asked to make a determination about whether the quantities you measured or derived were expected (and why), and whether or not your results support the hypothesis of the experiment. Was the objective of the experiment met? Always attempt to *quantify* your sources of error. This course requires basic plotting and data analysis skills with EXCEL software.

Conclusion: A good conclusion answers 3 questions:

- What did you do in the lab? Restate the purpose/problem. A brief description of how the goal was accomplished.
- What does your data say? Look at your data table or sketch and turn it into a sentence or two. Was the experiment successful? What are the sources of errors and uncertainties?
- What did you learn? This should answer the question posed in the purpose/problem.

Grade distribution: Lab reports will be graded as follows:

Title/Keywords	= 3
Objective	= 2
Procedure	= 5
Data and Analysis	= 35
Conclusion	= 5
Total	= 50

Final grade: Grades will be based on the following:

Lab Reports (dropping lowest)	70%
Formal Lab Report (see page 6)	15%
Final Exam	15%

90-100	A
80-89	B
70-79	C
60-69	D
Below 60	F

Attendance: Your attendance is required for each lab. Labs that you do not attend will not be graded. If you miss two consecutive labs or 3 overall, you will probably be dropped from the course (but do not count on being dropped by the instructor). If you anticipate an absence, attend one of the other lab sections. As a last resort, you may make arrangements with the lab assistant for an alternate time, but only after your first absence. Under no circumstances will there be make-up labs after the week in which they are due.

Disabilities: If you have any physical or learning disabilities, please contact the Center for Student Accommodations (CSA) at csa@pitttstate.edu.

Here are supplementary syllabus notes available to all PSU students.

Schedule:

Week 01	MEASUREMENT AND ERROR
Week 02	ACCELERATION WITH A CONSTANT FORCE
Week 03	NEWTON'S FIRST LAW OF MOTION
Week 04	COEFFICIENTS OF FRICTION
Week 05	NONCONSERVATIVE FORCES
Week 06	THE SIMPLE PENDULUM
Week 07	CONSERVATION OF MOMENTUM (ELASTIC)
Week 08	CONSERVATION OF MOMENTUM (INELASTIC)
Week 09	ROTATIONAL INERTIA
Week 10	ARCHIMEDES' PRINCIPLE
Week 11	HOOKE'S LAW AND SIMPLE HARMONIC MOTION
Week 12	MEASURING THE SPEED OF SOUND IN AIR
Week 13	COEFFICIENT OF LINEAR EXPANSION
Week 14	SPECIFIC HEAT OF SOLIDS
Week 15	**Final Exam (Dead Week)**

Plagiarism and Cheating:

Plagiarism and cheating are serious offenses and may be punished by failure on the exam, paper or project, failure in the course, and/or expulsion from the University.
For more information refer to the PSU Code of Student Rights and Responsibilities: Article 30, Academic Misconduct at

http://catalog.pittstate.edu/contentm/blueprints/blueprint_display.php?bp_listing_id=162&blueprint_id=124&sid=1&menu_id=7980

Please review the following syllabus supplement:

https://www.pittstate.edu/registrar/_files/documents/syllabus-supplement-spring-2019-updated-1-3-19-.pdf

Minimum Technology Requirement:

Canvas is required. Please click the link to a Canvas help page:

https://www.pittstate.edu/it/information-technology-services/canvas.html

Any technical difficulties, please contact Gorilla Geeks at

https://www.pittstate.edu/it/gorilla-geeks.html

DROPPING A COURSE OR WITHDRAWING FOR THE SEMESTER

Beginning the 12th week through the 16th week of full-term courses, individual courses cannot be dropped.

A student who does not officially withdraw from a course or from the university will be assigned an "F" grade in the course or courses concerned. These "F" grades will be included in the computation of the grade point average.

The dates for dropping courses that run fewer than sixteen weeks are proportionate to the length of the course (e.g. the last day to drop an eight week course would be the end of the sixth week). Consult your instructor or the Registrar's Office for questions about a specific course. For students who wish to withdraw from all classes after the 12th week of the term, the instructor must assign a grade of W or F.

To drop a course after the 5th day of class or for clarification on drop/add policies, contact the Registrar's Office, 103 Russ Hall, 620-235-4200 or registrar@pittstate.edu

Title: ____

Author: ____

Lab Partners: _____________________, _____________________, _____________________

Keywords:____

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Objective:____

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Procedure:____

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Conclusion:

Data and Analysis:

x_0 (m)	x_1(m)	$\Delta x = (x_0 - x_1)$[m]
0.50	0.32	0.18
1.00	0.52	0.48
1.50	0.88	0.62
2.00	1.09	0.92
2.50	1.45	1.05
3.00	1.65	1.35
3.50	2.01	1.49
4.00	2.21	1.79
4.50	2.57	1.93
5.00	2.77	2.23

Table 1: Initial height, final height, and change in height for different trials.

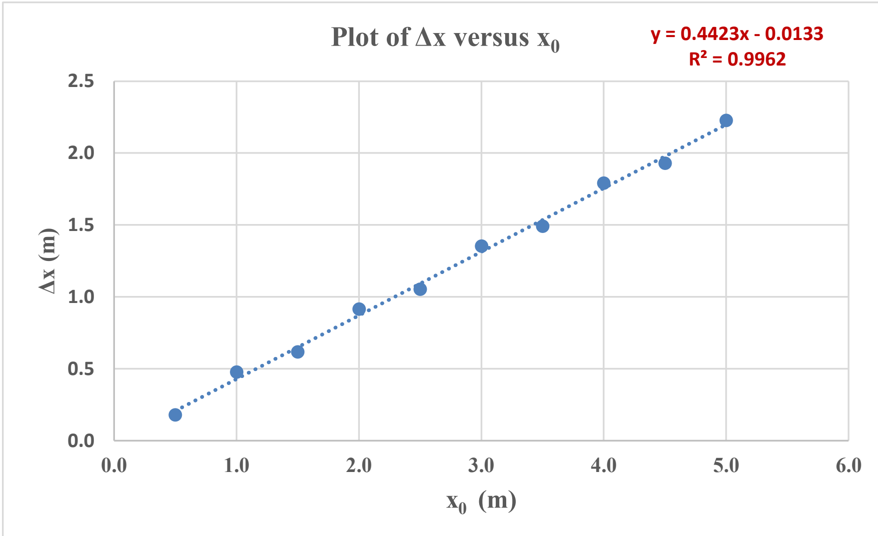

Figure 1: Plot of Δx versus x_0.

Calculations:

Experiment 1: Determination of Coefficient of Restitution of Concrete Floor

Author: Benjamin O. Tayo

Lab Partners: Eric Mullins and Michael Anderson

Abstract:

The coefficient of restitution (e) is an important quantity that characterizes the nature of different surfaces. It is a quantitative measure of the fraction of kinetic energy transferred to a surface when an object strikes the surface. e generally takes values in the range $0 \leq e \leq 1$. Our experiment revealed an e value of 0.75 for a concrete floor impacted upon by a tennis ball. The calculated e value was then used to predict a 44% energy transfer from the ball to the floor.

Keywords: Coefficient of restitution, kinetic energy, potential energy, conservation of energy

Objectives:

The initial height x_0 of a tennis ball above the floor is measured. The ball is released so that it strikes the concrete floor and rises to some final height x_1. The change in height is then calculated as $\Delta x = x_0 - x_1$. We expect a linear relationship between Δx and x_0, that is:

$$\Delta x = (1 - e^2)x_0 \tag{1}$$

This relationship will be tested, and if it holds, will be used to determine the coefficient of restitution e. Once the e value is known, we will use it to calculate the fraction of kinetic energy transferred from falling ball to the concrete floor.

Procedure:

The following apparatus was used: a meter stick and triple beam balance. The mass of the ball was recorded using a triple beam balance. The ball was dropped from some initial height x_0 which was measured using the meter stick. After bouncing off the floor, the final maximum height was recorded as x_1. The change in height due to kinetic energy loss was calculated using Eq. (1). Several trials were performed, for each trial corresponding values of x_0 and x_1 were recorded, and Δx was calculated for each data set.

Data and Analysis:

A total of 10 trials was performed. The data collected is tabulated in Table 1. Figure 1 shows a graph of Δx plotted as a function of x_0.

x_0 (m)	x_1(m)	$\Delta x = (x_0 - x_1)$[m]
0.50	0.32	0.18
1.00	0.52	0.48
1.50	0.88	0.62
2.00	1.09	0.92
2.50	1.45	1.05
3.00	1.65	1.35
3.50	2.01	1.49
4.00	2.21	1.79
4.50	2.57	1.93
5.00	2.77	2.23

Table 1: Initial height, final height, and change in height for different trials.

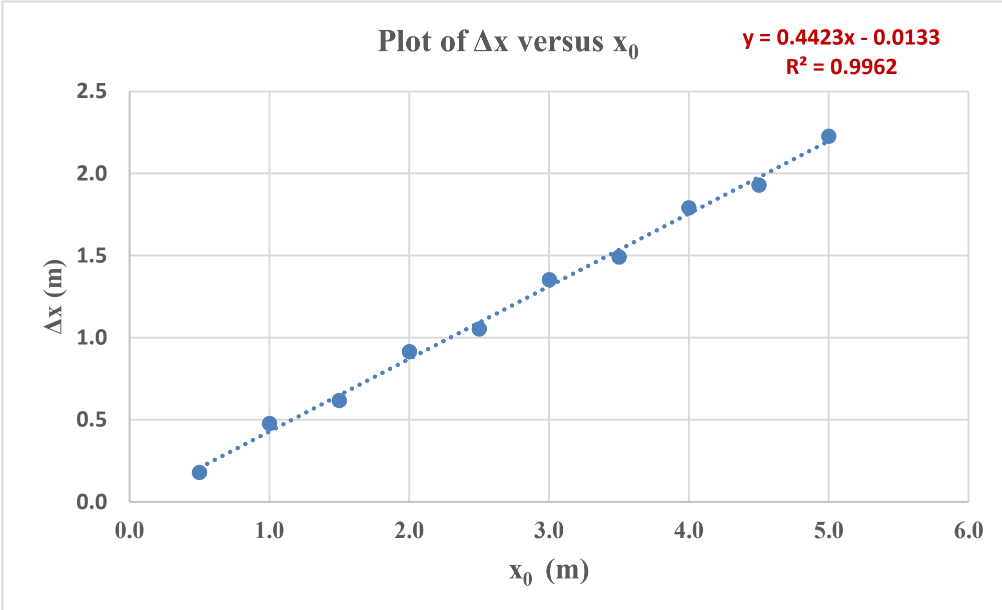

Figure 1: Plot of Δx versus x_0.

From Figure 1, we see that the best fit line fits the data pretty well, except for some slight deviations due to uncertainties. This result confirms the linear relationship between Δx and x_0 as predicted by Eq. (1). The slope (s) of the best fit line is $s = 0.44$. Using Eq. (1), we can show that the e value can be obtained from the slope using:

$$e = \sqrt{(1 - s)} = 0.75 \tag{2}$$

By applying the principle of conservation of energy, the fraction of kinetic energy transferred to the ball after it strikes the floor is given by

$$\left(\frac{E_1}{E_0}\right) = \left(\frac{v_1}{v_0}\right)^2 = e^2 \tag{3}$$

Using the value for e, we calculated the transferred kinetic energy as $E_1 = 0.56\, E_0$. This means that only 56% of the initial energy of the ball is transferred after the impact. About 44% of the energy is absorbed by the concrete floor.

Conclusion:

The experiment validates the theoretical prediction that Δx increases linearly with x_0. The data collected supports this notion very well as most of the data points fit nicely with the linear fit. The fitted line shows small deviations, which might be due to uncertainties associated with the measurement of the final height of the ball. The data was then used to obtain an e value of 0.75 for the concrete floor. Using our e value, we also predicted that 44% of the initial kinetic energy of the ball is absorbed by the concrete floor after the impact. Overall, the experiment was successful and the calculated values were meaningful. The experiment has helped me to gain useful insights on how energy is transferred in a collision process.