**PHYS 130 – Elementary Physics Laboratory I**

**Lab Location**: PSU, Yates Hall, Room 324

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**Course Description:** 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.

**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

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

**Final grade:** Grades will be based on the following:

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

**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](https://www.pittstate.edu/registrar/_files/documents/syllabus-supplement-fall-2018) 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)** |

**Title: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

Author: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Lab Partners: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Keywords**:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Objective:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Procedure:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Conclusion:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Data and Analysis:**



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 $Δx=x\_{0}-x\_{1}$. We expect a linear relationship between $Δx$ and $x\_{0}$, that is:

 $ Δx=\left(1-e^{2}\right)x\_{0} $ (1) (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 $x\_{0}$.



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$ (2) (1)

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

 $ $ $\left(\frac{E\_{1}}{E\_{0}}\right)=\left(\frac{v\_{1}}{v\_{0}}\right)^{2}=e^{2}$ (3) (1)

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.