Unit 2: Bouncing Ball

**Course-wide Learning Goals:**

By the end of the three-course intro lab sequence, students should be able to:

1. Collect data and revise the experimental procedure iteratively, reflectively, and responsively,
2. Evaluate the process and outcomes of an experiment quantitatively and qualitatively,
3. Extend the scope of an investigation whether or not results come out as expected,
4. Communicate the process and outcomes of an experiment, and
5. Conduct an experiment collaboratively and ethically.

### Objectives:

By the end of these activities, you should be able to:

* Choose a model to test from theory or predictions
* Make predictions about expected measurements and use the predictions to check whether data make sense
* Decide how to compare the data to a model through graphical or quantitative analysis
* If data do not agree with the model, extend the scope of the investigation to determine plausible explanations for disagreements (e.g. mistakes in the measurement process, analysis methods, or limitations of the model)
* If data do agree with the model, extend the scope of the investigation to check whether results are reproducible under the same conditions, with higher precision, or in other situations (different data ranges, other variables)

**Pre-lab Activity (Due by 11:59pm the day before your lab section meets):**

1. Reflect on your findings and process from last week. To begin your reflection, consider the following questions: How did your data support the conclusions that your group came to? What did or didn’t go as expected? How did your respond? What new questions do you have because of your investigation? What questions were you able and unable to answer?
2. What is a model? What is the role of a model in an experiment? Answer these questions in detail by using specific examples from lecture, lab, other classes, your own experiences, etc.

Instructor Notes:

Begin with a whole class discussion about models in physics. Have students discuss what they wrote in the prelab as well as respond to other students’ ideas about models. A model is defined as a representation (or coordinated set of representations) of a phenomenon that can be used to make explain, predict, and describe a phenomenon (or set of phenomena). These representations may involve pictures, words, graphs, equations, data, or lots more

Before your students launch into their model development, emphasize that they should be developing *the simplest model* for the first iteration of their experiment. Presumably the simplest model is that the ball is in free fall, bounces (without any change in energy to the ball), and resumes free fall, returning to the point that it was dropped and falling again. Encourage your students to quickly converge on a model and begin testing that model.

Once most groups have finished developing their models, pause the class for a discussion about these models. This provides a chance for students to discuss the simplest model as well as allow groups that have developed complicated models to adjust their initial plans.

For the remainder of the lab, you should encourage students to continue to iterate and extend their investigations. If multiple groups have the same question, a class discussion may be a fruitful way to address these questions using students’ contributions. Support groups as needed, but allow students to make the decisions in their processes.

|  |
| --- |
| **Instructor Time Stamp: 10 minutes Activity I: Model building** |

In this lab, you will be releasing a ball above the ground and collecting data on its motion as it bounces. In your groups, come up with a model that describes the velocity of the ball throughout its trajectory. For now, come up with the **simplest model you can**, identifying all the necessary assumptions that you must make. What predictions can you make from your model about the ball’s velocity throughout its trajectory?

Use your whiteboard to sketch out the elements of your model including a list of assumptions, representations (graphs, diagrams, equations, etc.), and predictions. Be ready to present your model to the class.

Describe your model in your lab notes. Devise a plan for testing your model using data on a ball’s position over time and record your plan in your lab notes. Discuss your plan with another group and record any changes you make to your plan after the discussion.

**Note**: To convert your position versus time data to speed versus time, how do you know what speed is associated with what time?

|  |
| --- |
| **Instructor Time Stamp: 30 minutes Activity II: Evaluating the model** |

Implement your plan by collecting data on the position of a falling basketball and beach ball over time. In each situation, record your observations, and ways in which your method differs from your plan. How do the predictions from your model compare to your data in each case? How do you know?

|  |
| --- |
| **Instructor Time: At least half of the lab session Activity III: Reflect on the models** |

Between the two data sets (basketball and beach ball), how do your results inform the simple model you built? In what ways is your model useful, predictive, or insufficient? Support your claims using data you collected for both the basketball and beach ball.

In your group, brainstorm what else may be going on that your model did not account for in this situation. How might you test a new, revised model? How might you collect data to develop a new model based on data? With the remaining time, test at least one or two of your group’s proposals. Check in with other groups to see what other ideas have emerged.