**Unit 5: Project Lab**

**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:

* Brainstorm with your group to develop a diverse set of ideas in order to make decisions
* Use previous results to inform the design of a new experiment
* Decide how to measure data including how much data to collect to reduce sources of uncertainty, systematics, or mistakes
* Extend the scope of an experiment to check if there is “new” physics, to isolate and test components of the system, and/or to design new experiments/tests to explore other explanations
* Describe the experimental goals, process, data, results, and conclusions including justification for all decisions made
* Present findings as arguments supported by and following from evidence

**Pre-Lab Activity I (Due the day before your lab section during the week of Nov. 6-10 by 11:59pm).**

1. Describe how the labs so far have introduced ideas about physical and measurement models. How would you define a model of a physical system and a model of a measurement system? How do assumptions or approximations about either impact our investigations about the physical world? What are possible activities that we can do to make sure we are making valid and reliable conclusions?
2. Propose **two research questions** to investigate with your group during the next two weeks. These research questions must build on or extend on the labs that you have completed this semester: Pendulum for Pros, Terminal Velocity, Hooke’s Law, or Collisions. As part of your proposal, describe why you want to investigate these questions based on what you or others found in previous labs.

**Pre-Lab Activity II (Due the day before your lab section during the week of Nov. 13-17 by 11:59pm):**

1. Complete the questionnaire found at the following link: <https://cornell.qualtrics.com/jfe/form/SV_6mOy7U2ApzVn2fP>
2. Reflect on your experience during lab last time. What did and didn’t go as expected? How did you respond? What new questions do you have because of your investigation? What will you do next? Why? What questions were you able and unable to answer? How will you improve your measurements?

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| **Activity I: Narrowing your research question** |

1. **Develop a single proposal**

Within your group, narrow your research question to settle on a single idea within your group. To do this, use contributions from each group member’s pre-labs to determine whether there were common threads for potential investigations.

Draw upon each person’s ideas for improving measurements and analyzing data to strengthen your group’s proposal. When you have reached consensus on a general research question and ideas for data collection and analysis, record a description in your group’s lab notes.

**Instructor Notes:**

“Speed dating” is not easy to coordinate so don’t try to have every group check-in with every other group. In each table cluster, have one group stay stationary throughout and the other group rotates in clockwise. Set a timer and loudly tell groups when to rotate. It’s fine if three groups end up talking together at once. Encourage the groups to inform other groups when they have heard of groups with similar research questions. This should not take more than 10 minutes in total.

1. **Speed dating**

Next your instructor will facilitate “speed dating” as a way to learn about other groups’ investigations and to reduce replication. You will meet with each group in the class for **one minute** to discuss plans. If your plans overlap, find a way to divide and conquer answering the research question.

You are encouraged to check in with other groups—throughout both weeks—about their findings. To begin, determine general directions that will make your own group’s investigations unique. It is helpful to sit near groups that are investigating similar research questions for efficiency.

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| **Activity II: Conducting your investigation** |

Carry out your investigation and extend your investigation after obtaining results. Record all your decisions in your lab notes including improvements to your measurements, how and why you collect and analyze data, reasons for changes that you make to your research question and/or experimental design, etc.

At the end of the first week, you will report out to the class to answer “where are you at?” Each group will be given **one minute** to describe their research question and to summarize their progress at this point in the activity.

In the final lab meeting (Nov. 30 or Dec. 1), your group will present for **three minutes** to describe your research question, experimental process, one interesting finding from your investigation, and one direction you recommend others to pursue in a future investigation (such as students taking Physics 1116 next semester!).

On LabArchives, locate the assignment for the final presentation. You may place any diagrams or tables that your group would like to project during your final presentation. Two rules: (1) No full sentences of text and (2) Submit by the end of lab on either Nov. 16 or 17.