7.2: Activities

Things You Will Need

Nothing! All the data has been meticulously collected for you.

Finding μ_K Two Ways

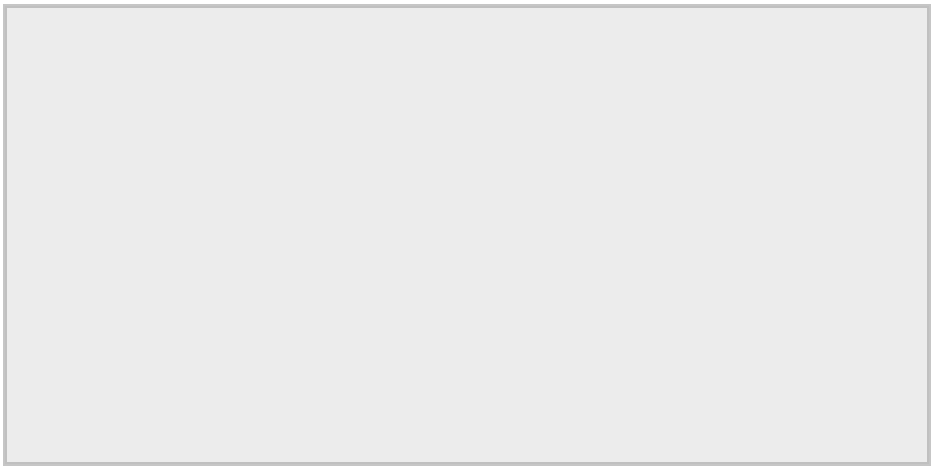
As stated in the Background Material, the goal of this lab is to measure the coefficient of kinetic friction between a cardboard box and the tabletop across which it slides. We will cause the box to slide in two different manners, and compare the results for confirmation.

The first method is as straightforward as it gets. We will pull the box horizontally across the horizontal tabletop, and measure the magnitude of the pull. From measurements of the box's mass and the reading on the scale, we will do the calculation to determine μ_K. We will also include an analysis of uncertainty in this measurement.

Figure 7.2.1 – Block Pulled Horizontally by Spring Scale

The second method involves a more complicated mechanism. We will swing a pendulum from a horizontal position, and allow it to strike the box when it is vertical. The impulse imparted to the box will cause it to slide some distance before coming to rest. The end of the pendulum consists of a bag of sand, so it deforms during the collision. With measurements of the mass of the box, the mass of the bag of sand, and the distance the box is displaced, we once again will compute (\mu_K\). Again a measure of the uncertainty in this experiment will be included.

Figure 7.2.2 – Block Slides after Being Struck by Pendulum



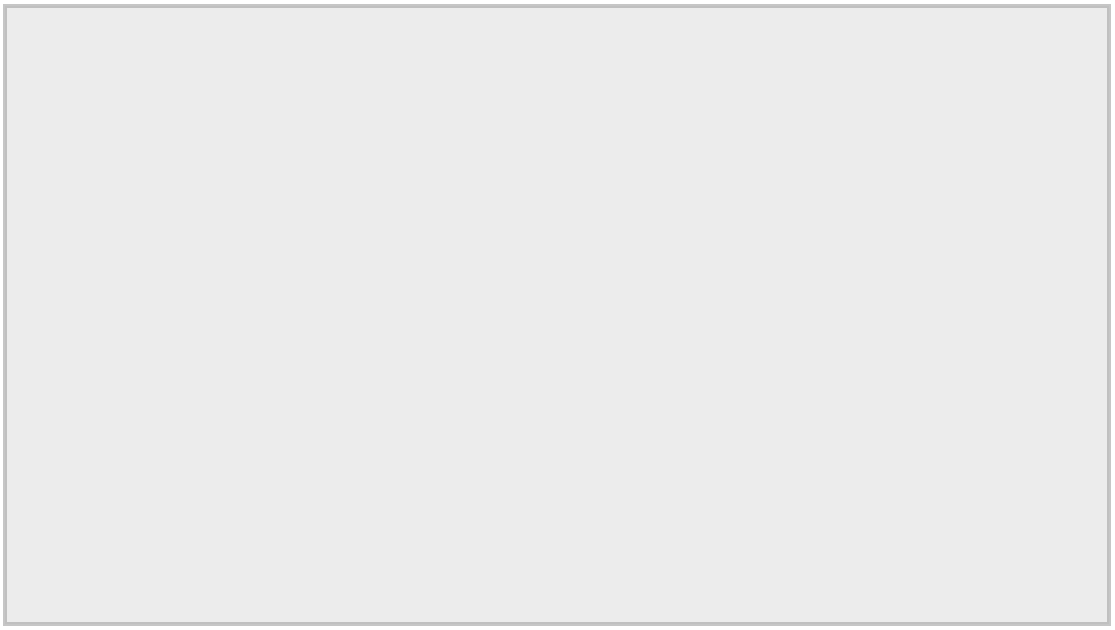
The Data

The data for these experiments are given below in the form of pictures and gifs, and you are expected to extract the necessary information from them.

Experiment #1

- **the physical process** – In case it isn't clear from the video, it should be noted that the spring scale is pulled horizontally at a constant speed, and the markings on it indicate that it measures grams-force (1 gram-force is the force that the Earth's gravity exerts on 1 gram of mass).

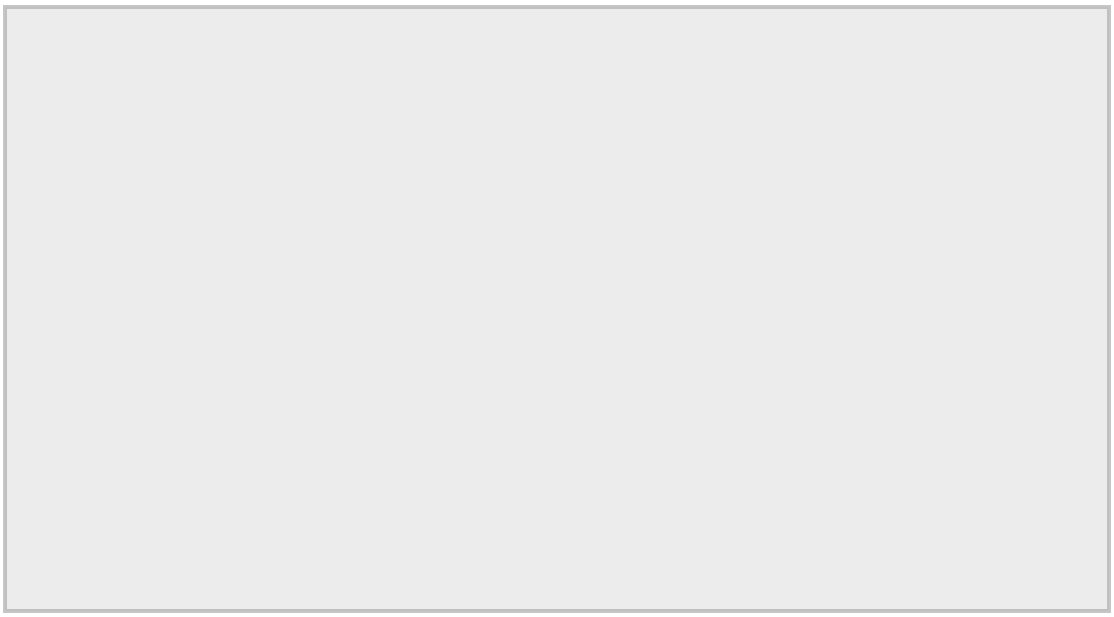
mass of box – Can be read directly from the scale.



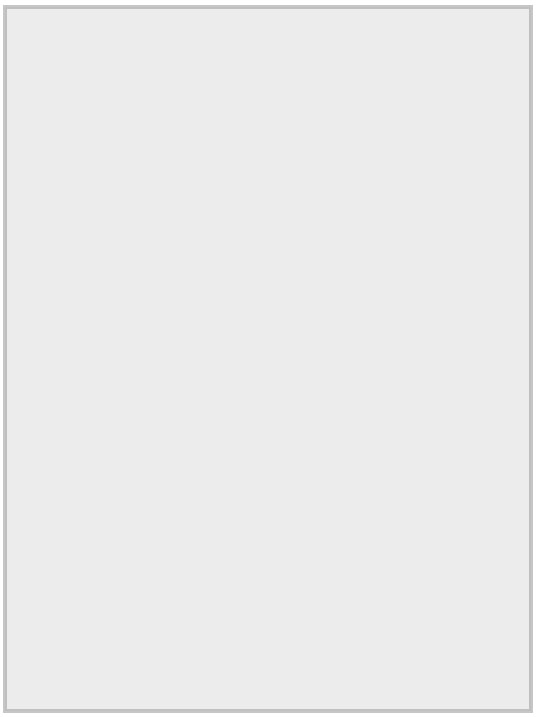
Experiment #2

- **the physical process** – There may be important clues here regarding the kind of collision that occurs. Also note that the box starts with its front-facing side flush with the tape on the table. The picture of the box displacement later comes directly from this run.

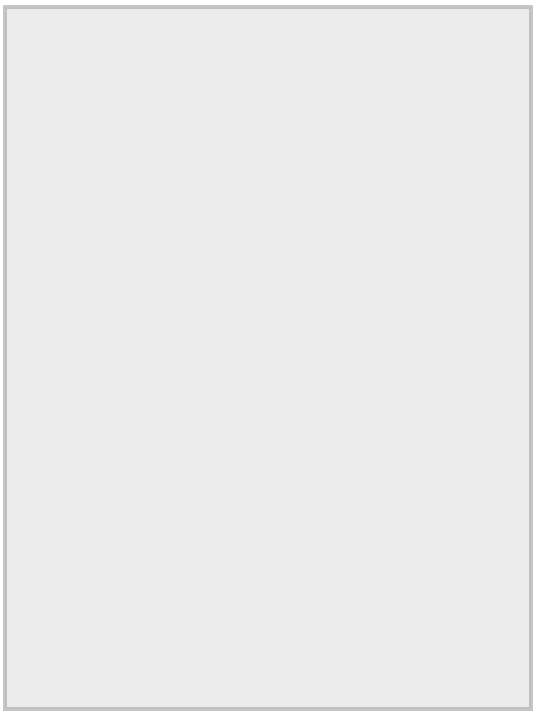
- **mass of sandbag** – Can be read directly from the scale.



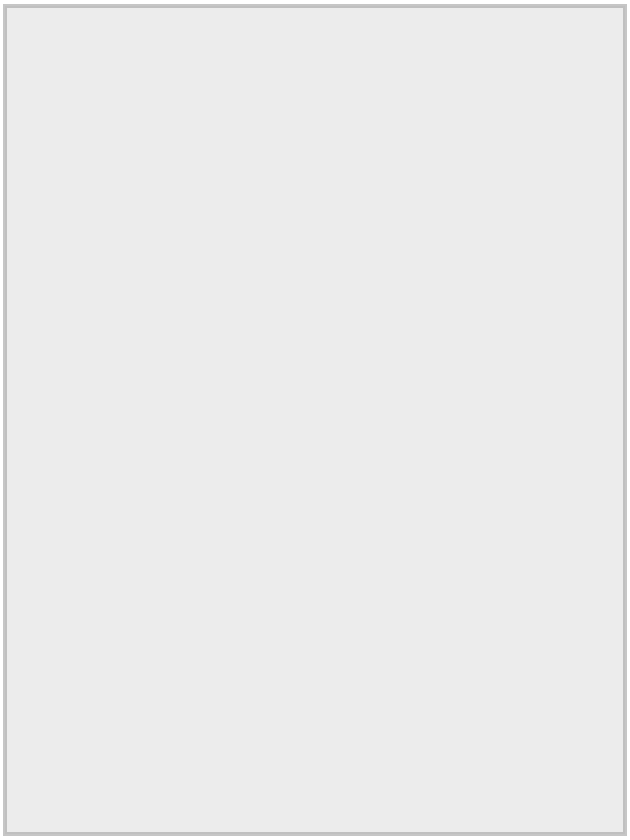
- **maximum height of sandbag** – The sandbag is released from a height that is level with the top of the string.



- **minimum height of sandbag** – This measurement is taken by the same meter stick in the same position as the previous measurement.



- **displacement of box** – The box rotated slightly after the collision, but the displacement of the center of mass is approximately measured.



Data Analysis and Additional Discussion

In each of the experiments, the first step is to "solve the physics problem." You are encouraged to do this using *variables only*, and only after you have a solution should you plug in the numbers to have from the data.

1. Experiment #1 – dragging the box with a scale
    a. Solve the physics problem (free-body diagram, Newton's laws, etc.) and solve for the coefficient of kinetic friction using the data from experiment #1. Along the way, comment on the important features of the experimental procedure that make this calculation correct.
    b. Estimate the absolute uncertainties for the two measured quantities in this experiment, and convert them into percent uncertainties.
    c. Determine the "weakest link" percent uncertainty and record the result of the experiment in the form:

$$\mu_K = 0.\times\times\times \pm \times\times.\times\,\% \tag{7.2.1}$$

2. Experiment #2 – hitting the box with a pendulum
    a. Solve the physics problem (work, energy conservation, momentum conservation, etc.) and determine the coefficient of kinetic friction using the data from experiment #2. Along the way, comment on the important features of the experimental procedure that make this calculation correct.
    b. Estimate the absolute uncertainties for the four measured quantities in this experiment (note: the two height measurements for the sandbag combine into a single useful measurement), and convert them into percent uncertainties.
    c. Determine the "weakest link" percent uncertainty and record the result of the experiment in the same form as above.
3. Compare the results, and determine whether they are in agreement to within uncertainties.

Lab Report

Download, print, and complete this document, then upload your lab report to Canvas. [*If you don't have a printer, then two other options are to edit the pdf directly on a computer, or create a facsimile of the lab report format by hand.*]
