4.2: Activities

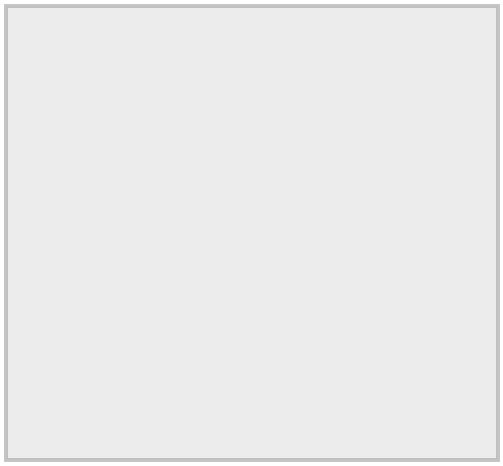
Things You Will Need

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

Finding μ_S Two Ways

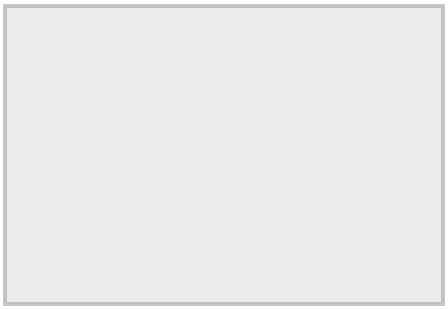
We will be seeking to find the coefficient of static friction between a block of wood and a swatch of carpet. We will do this with two separate experiments, a check for consistency between the two results. The first experiment will consist of gradually adding weight to a string that (with the help of pulleys) pulls the block up an inclined plane whose surface is the carpet swatch. We will add weight gradually, until the block just starts to slide up the plane, recording both the last weight that didn't move the block and the weight that does move it, and declare the weight halfway between these as the "trigger weight" (m) that hits the maximum static friction force. We will do this at several heights (y) for the top of the plane, to diversify our data, since we don't expect the coefficient of friction to depend upon the angle of the plane.

Figure 4.2.1 – Block Pulled Up the Plane



The second experiment will involve the same block on the same inclined plane of carpet, but instead of changing the angle and measuring the weight required to move it up the plane, we will remove the string, pulleys and hanging mass, and just raise the plane very slowly until the block starts to slide down, measuring the height (y) at which it begins to slide. We'll repeat this process 4 times, to get enough data for an average and an approximate statistical uncertainty.

Figure 4.2.2 – Block Slides Down the Plane

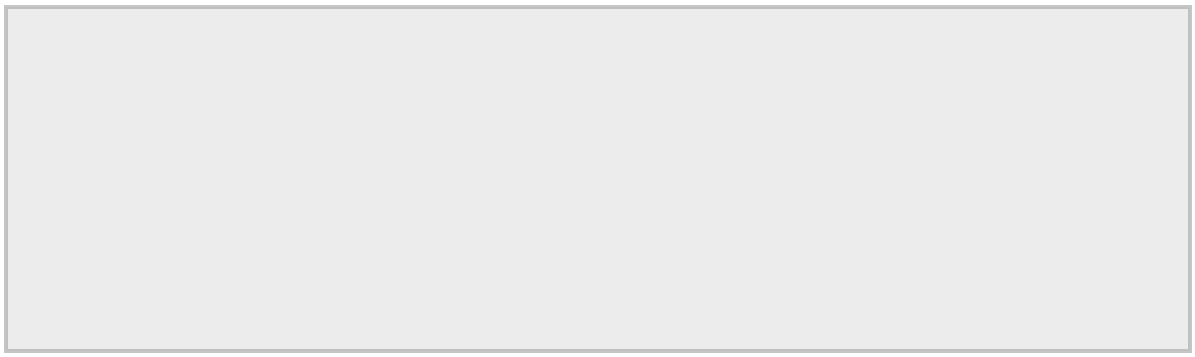


We can use free-body diagrams and Newton's laws to solve for μ_S in terms of y, L, and m for these two cases, and compare the results to see if they agree.

The Data

All the raw data for these two experiments is given in the table below. An extra column for the angle θ that the plane makes with the horizontal has been included to aid in the calculation of μ_S. [*Note: In upcoming labs, you will be expected to create your own tables from scratch!*]

Figure 4.2.3 – Data Table



It should be noted that normally the uncertainties in the measured quantities L, M, m, and y would be noted, and then "propagated" (perhaps using the "weakest link rule" described in the Background Material) to determine the uncertainty in the calculated quantity μ_S. In this case, however, the rug involved could display different coefficients of static friction for different runs, depending upon whether it is fluffed-up or matted down, or if the grain was slanting one way or another. These random elements that vary across runs can only be accounted-for statistically, so it is easier to do the statistics after the final values are computed for each run.

Data Analysis and Additional Discussion

1. Fill in the empty spaces in the data table given above. There is quite a bit of "physics work" that needs to be done to get from the raw data to the eventual result (free-body diagrams, application of the maximum static friction condition, etc.), and all of that needs to be included for the analysis to be considered complete. The text references given in the Background Material should be very helpful in this regard.
2. Determine (and explain) whether the results of the two experiments are in agreement, to within uncertainty. See the Background Material for the proper method for determining this.
3. It is mentioned above that there are additional uncertainties brought into the experiment beyond the inexactitude in the measurements taken. For example, in the second experiment, the only measurements needed are the length of the ramp L and the height to which it is raised y. The length of the ramp has a very small uncertainty, so we can treat it as essentially exact. The only uncertainty in measurement of consequence is therefore that of the variable y. These measurements were less precise (raising the ramp slowly and noting the height at which the block begins sliding is not the same as measuring the length of the motionless plank), so they are rounded to the nearest half-centimeter. Compute the percentage uncertainty of the height measurement and the percentage uncertainty of the coefficient of static friction for that experiment, and show that the latter is significantly larger, confirming that random error likely creeps into the condition of the rug between runs.
4. While it is difficult to do without actually being present to take the data, speculate about what might be sources of error for the experiment. We have already mentioned the changing condition of the rug, so focus your consideration on some of the other elements of the experiment. Make suggestions for methods that might reduce these errors.

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.*]