OALG 7.7.3 Application experiment: Measuring the coefficient of kinetic friction

The goal is to use your knowledge of energy and momentum to determine the coefficient of kinetic friction between a tissue box and the table in the following video. [https://mediaplayer.pearsoncmg.com/assets/_frames.true/sci-phys-egv2e-alg-7-7-3].

The flour-filled balloon has a mass of 54.7g, the tissue-box has a mass of 161.1g.

Observing the experiments

Observe two experiments that can be used to determine the coefficient of kinetic friction. For each experiment:

Constructing the mathematical model

Start with the experiment with the flower balloon hitting the box and the box sliding to a stop. Think of how you can analyze the process conceptually (using energy and momentum bar charts) to find the coefficients of kinetic friction and then how you can convert these bar charts into mathematical representations. The following steps might help you:

a. Divide the process into three smaller processes that each involves one central physics idea. Represent each smaller process with a relevant bar chart (think of whether energy bar chart of momentum bar chart will be easier to analyze mathematically). Carefully choose your system for every sub-process.

b. Once you have the bar charts, convert them into mathematical representations (models). Check if what you wrote will help you determine the coefficient of kinetic friction.

c. Identify the physical quantities you will need to measure in order to determine the coefficient of kinetic friction.

d. Repeat the process for the second experiment (pulling the box with the scale). Here you might want to use the force diagram to construct the mathematical model.

e. What assumptions did you make in your mathematical models? Specifically, what is the effect making each of them will have on the result produced by your mathematical model (will it make the calculated value smaller, larger, or randomly different than the real-world value)? Explain your reasoning.

Collecting data

a. Measure the physical quantities you identified in parts **c** and **d** in the previous step.

c. Record the data. What is the uncertainty in each measurement?

d. Use the mathematical procedure you devised to determine the coefficient of kinetic friction in both experiments. Estimate the uncertainty in your results.

e. Decide if the results of the two experiments are consistent or not. What is your judgment about the model you used to represent the situation shown in the video?

If you need to improve the mathematical model

a. Think about assumptions you made in your mathematical models. Which of your assumptions is least likely to be valid? Describe how you will revise part of your mathematical procedure to deal with this. What additional measurements will you need to make?

b. Construct force diagrams, and energy and/or momentum bar charts for your revised mathematical method.

c. Come up with a new equation for the coefficient of kinetic friction that incorporates your revisions. Again, do not plug in numbers.

d. Make any additional measurements you need, and then use your new equation to determine a revised value of the coefficient of kinetic friction.

e. Now are the results of the two independent methods consistent? Now what is your judgment about the mathematical model?

f. Are any of the other assumptions in your revised mathematical model questionable? How could you revise your mathematical procedure further to deal with these?