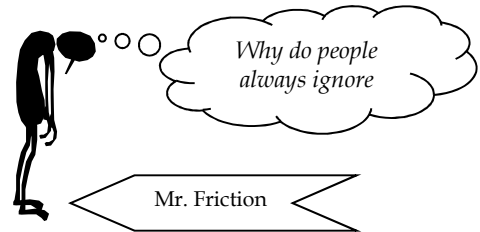


Friction Action!



Objective:

1. Determine how an object's mass affects the friction it experiences.
2. Compare the coefficient of static friction to the coefficient of kinetic friction for each friction block material to determine whether it is easier to make an object start to move or to keep a moving object in motion at a constant velocity.
3. Determine the coefficients of static friction and kinetic friction for two different friction materials when moved across aluminum and compare those coefficients to determine which material experiences more friction.

Safety: BE SURE TO KEEP YOUR SMART CART UPSIDE-DOWN WHEN YOU'RE NOT ACTIVELY USING IT TO RECORD DATA.

Materials:

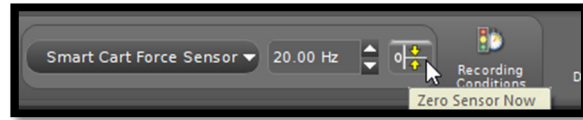
Obtain a handy PASCO set up including...

- ☆ An aluminum track!
- ☆ Two friction blocks with different materials on their bottoms!
- ☆ A PASCO Smart Cart with a hook attachment!
- ☆ Some string!
- ☆ Three bar masses!

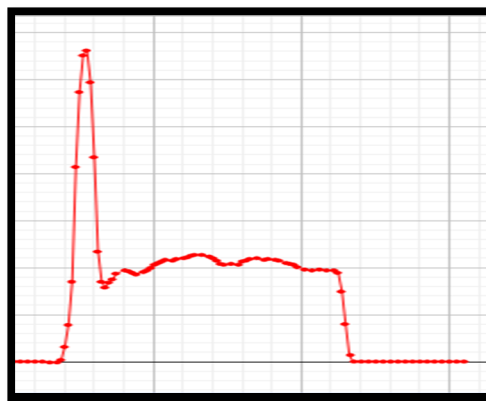
Procedure:

1. Pick one of the friction blocks. Tie a small piece of string through the hole on the end of the friction block.
2. Launch Capstone and turn on your Smart Cart. Click on "Hardware Setup" and connect to your Smart Cart.
3. Drag a graph onto the screen and put "Force" on the y-axis.
4. Place both the friction block (material side facing down) and the Smart Cart on the track so that the hook faces the friction block. Place one bar mass in the friction block. Attach the friction block to the Smart Cart by looping the friction block's string through the Smart Cart's hook. **KEEP YOUR HAND ON THE SMART CART SO THAT IT DOESN'T ROLL AWAY.**

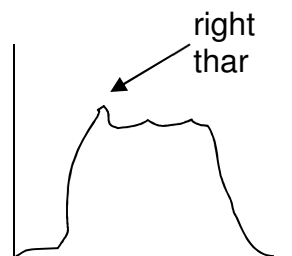
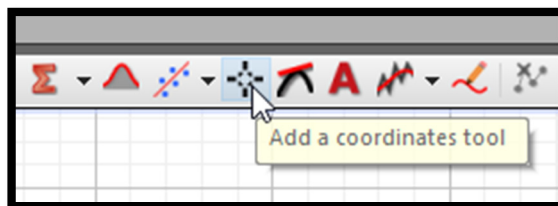
- Make sure there is no tension on the string between the Smart Cart and the friction block. (That's important.) At the bottom of the screen click on the yellow and white icon shown below to zero the Smart Cart's force sensor. (This means that when no force acts on the sensor, the graph will record the force as 0.00 N. This calibration is an important step and prevents systematic error.)



- Start recording, wait two seconds, and then slowly pull your car so that it begins to drag the friction block. Once your block starts moving, you don't have to drag it very far. Ten-to-twenty centimeters is plenty. (Pro-tip: It is essential that you move your car with as steady a velocity as possible.) Then stop the recording.
- Look at your graph. After an initial spike, the graph should be fairly flat as shown below. If it is, proceed to step nine. If it is not, proceed to step eight.

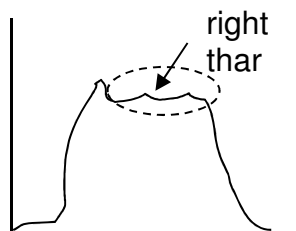


- You stink at this game. Erase your last data run and then go back to step six.
- Now it's time to find the force required to make your friction block start to slide. We'll use the Coordinates Tool to find the ordered pair at the moment of maximum force. Turn on the Coordinates Tool as shown and measure the force at the point indicated on the sketch below. This is the maximum static friction. Record it in Table 1.

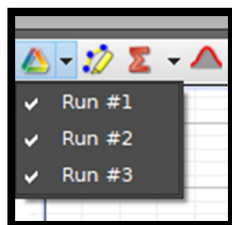


- On your graph highlight the flat portion of the graph after the initial spike as shown below. This represents the force you used to pull against kinetic friction once the block started to move. Record the mean (average) of that highlighted portion as the kinetic friction. (If the

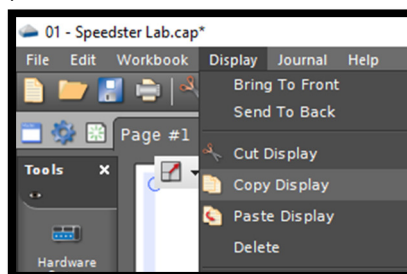
computer isn't showing the mean of the highlighted portion, click the dropdown menu by the Σ button and select "Mean." Then click the dropdown menu again to turn it off. Finally click the Σ button to show the mean.) Enter the mean force for this kinetic friction in the appropriate spot in Table 2.



11. DO NOT DELETE ANY DATA.
12. Repeat steps four through eleven by adding an additional bar mass to the friction block so that there are two bar masses in the block.
13. Repeat steps four through eleven by adding a third bar mass to the friction block.
14. Perform measurements and calculations to complete all cells in Table 1 and Table 2.
15. Near the top-left of the graph area, look for a rainbow-colored triangle. First click the rainbow triangle. Then click the small, black triangle to the right of it for a drop-down menu. You should see all three runs. Click on all three so that there is a checkmark by each. LAST click the rainbow triangle again. You should see all three data runs on your graph. Stretch your x- and y-axis and reposition the origin as needed so that your data fills the graphs from left-to-right and top-to-bottom.



Polish the graph up to prepare to export it to your lab document. In the bottom left of the graph area you should see a place to give the graph a title. Click and enter a title. (Remember that graphs are always named *Dependent Variable vs Independent Variable*. IN THIS CASE ALSO identify the type of material that was on the bottom of your friction block.) At the top of the page, find the Display menu. Click on this menu and then select "Copy Display." You can now paste the graph into a document. (For now it may be convenient to open a Word document and save the image there. Eventually you can move the image to another document as needed.)



16. Now remove your friction block and exchange it for one with a different material on the bottom. Repeat steps one through fifteen to fill out Table 3 and Table 4.

Data Tables & Graphs:

In a spreadsheet, create the following data tables:

- ✚ A table showing the maximum static friction and the coefficient of static friction for the first block with the three different masses. This table should also show the average coefficient of static friction for these three runs. Do not include weight and normal force in the table.
- ✚ A table showing the kinetic friction and the coefficient of kinetic friction for the first block with the three different masses. This table should also show the average coefficient of kinetic friction for these three runs.
- ✚ A table showing the maximum static friction and the coefficient of static friction for the second block with the three different masses. This table should also show the average coefficient of static friction for these three runs. Do not include weight and normal force in the table.
- ✚ A table showing the kinetic friction and the coefficient of kinetic friction for the second block with the three different masses. This table should also show the average coefficient of kinetic friction for these three runs.
- ✚ Also include a screen shot of the three data runs for each of your friction block materials.

Calculations:

- ✚ Sample calculation of how you calculated the coefficient of static friction for one of your data trials. (For example, how you did you do your calculations going across one row of one of the data tables.)
- ✚ Sample calculation of how you calculated the coefficient of kinetic friction for one of your data trials.

Conclusion: Be sure to address each of the objectives.



Our Data Wonderland

NOTE: THESE DATA TABLES ARE SIMILAR TO BUT NOT IDENTICAL TO THE ONES YOU WILL INCLUDE IN YOUR LAB REPORT. THEY ARE ONLY INCLUDED HERE TO HELP YOU ORGANIZE YOUR INFORMATION WHILE DOING THE LAB. DO NOT MERELY COPY THESE EXACTLY INTO YOUR LAB REPORT. READ WHAT'S REQUIRED IN THE DATA TABLES & GRAPHS SECTION.

Table 1 – Maximum Static Friction of **(Write in the material)**



	Mass (kg)	Weight (N)	Normal Force (N)	Maximum Static Friction (N)	Coefficient of Static Friction (Maximum Static Friction ÷ Normal Force)
Tray + 0.250 kg					
Tray + 0.500 kg					
Tray + 0.750kg					
Average Coefficient of Static Friction:					

Table 2 – Kinetic Friction of...

	Kinetic Friction (N)	Coefficient of Kinetic Friction (Kinetic Friction ÷ Normal Force)
Tray + 0.250 kg		
Tray + 0.500 kg		
Tray + 0.750kg		
Average Coefficient of Kinetic Friction:		

Guide your thinking regarding objectives one and two:

- As mass increased, what happened to the friction force? (Look at the force column, not the coefficient column.)
- Which average coefficient was greater, the one for static friction, or the one for kinetic friction? Does that mean it was harder to make the object start to move or to keep it moving?

Table 3 – Maximum Static Friction of (Write in the material)

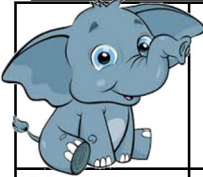

	Mass (kg)	Weight (N)	Normal Force (N)	Maximum Static Friction (N)	Coefficient of Static Friction (Maximum Static Friction ÷ Normal Force)
Tray + 0.250 kg					
Tray + 0.500 kg					
Tray + 0.750kg					
Average Coefficient of Static Friction:					

Table 4 – Kinetic Friction of...

	Kinetic Friction (N)	Coefficient of Kinetic Friction (Kinetic Friction ÷ Normal Force)
Tray + 0.250 kg		
Tray + 0.500 kg		
Tray + 0.750kg		
Average Coefficient of Kinetic Friction:		

Guide your thinking regarding all three objectives:

1. As mass increased, what happened to the friction force? (Look at the force column, not the coefficient column.) Was this consistent with what happened to the other block?
2. Which coefficient was greater, the one for static friction, or the one for kinetic friction? Does that mean it was harder to make the object start to move or to keep it moving? Is this consistent with your results from the other friction block material?
3. Which material had a greater average coefficient for static friction? Which material had a greater average coefficient for kinetic friction? What does this allow you to conclude about which material experiences more friction when moved across aluminum?