**Friction lab: Who’s the fastest on the slide?**



Anywhere there is a playground with a “double slide” (such as the one shown above), kids will argue about who can get down the slide the fastest. Some will predict it is the biggest kid. Some will say it is the thinnest kid. Inevitably they will compete and when they do the results are hard to predict. The size, weight, and shape of the kid does not seem to matter. Why not?

For the first part of this experiment you will need an inclined dynamics track, a couple of dynamics carts, a block of wood, some weights, masking tape, and a timing device (which could be a motion sensor or photogates). If you have a combination of low mass carts (usually 250 g) and high mass carts (usually 500 g) that’s even better.

For the second part of this experiment you will need a force sensor or Vernier WDSS device.

**Preparation:**

Use your dynamics track to make an inclined plane. The incline should be steep enough that your block of wood will slide down it freely, without stopping or slowing down. Make sure the track is stable so that the incline won’t change during the experiment. You may need a ring stand and some clamps.

If you are using photogates as a timing device, set them up so that they are far enough apart to time the block of wood and/or the dynamics carts as they slide down the ramp. If you are using a motion sensor, set it up so it can time objects sliding down the ramp.

**Part I: Just sliding**

Part I a: “No friction” (or very little friction)

For this part you need to compare two low-friction dynamics carts of different mass. Use a plastic cart and a metal cart if you have them. If not, simply add weight to one cart so that it has a mass which is close to double the mass of the other.

Step 1) Measuring just one thing. Choose your lower-mass cart (Cart A) and decide how you are going to measure the time required for it to slide “down the ramp.” For example, you could choose to record the amount of time it takes the cart to slide one meter starting from rest. Once you have decided on what time to measure, measure this for *the same cart* five different times. Your answers will be similar but not identical. Record the mass of Cart A and five times below.

Step 2) Repeat the experiment above with your other cart (cart B). This cart should be roughly twice the mass of Cart A. Record the mass of Cart B and five times below.

Step 3) Were your answers significantly different? Was the average of your measurements for Cart A significantly different from the average for Cart B? Was the difference greater than the range of measurements for each cart? Check to see if your results for this part are consistent with those of your classmates.

Step 4) *Use your results* for Cart A and Cart B to calculate the acceleration of each on the ramp. *As a separate exercise* you may also want to make measurements of your ramp to see whether these acceleration values make sense to you.

Step 5) Draw a free-body-diagram for Cart A and a separate one for Cart B when they are moving down the ramp. Are all of the forces in your diagram for Cart A the same magnitude as the forces in the diagram for Cart B?

Step 6) Why do you think the results came out the way they did? Explain in words. Come up with your own explanation. Your explanation should be consistent with the results from Step 1 and Step 2 as well as your work in Step 5. Discuss this with your classmates and instructor.

Part I b: “More friction”

Repeat your work from Steps 1 through 6 above but replace the carts with a block of wood. Use only one block of wood. “Block A” will be the block of wood all by itself. “Block B” will be the same block of wood with enough weights taped to the top of the block to double its mass. You want the surface that slides along the ramp to be the same for Block A and Block B, so make sure the tape does not touch the bottom surface of the block.

Try to arrange for Block A to have the same mass as Cart A, while Block B should have nearly the same mass as Cart B.

Before you begin, predict:  
In this case there is significant friction between the block and the ramp. Do you think your results for Block A will be the same as your results for Block B? Why or why not|?

Step 1) “Block A”, mass and five times

Step 2) “Block B”, mass and five times

Step 3) Are they significantly different?

Step 4) Calculate the acceleration(s)

Step 5) Free-body diagrams…

Step 6) What do you think? (Don’t worry if you don’t know the answers. Record your thoughts.)

Step 6 a) Was there a significant difference between Cart A and Block A? Why or why not?

Step 6 b) Was there a significant difference between Block A and Block B? Why or why not?

**Part II: Measuring friction**

Get a force sensor or a Vernier WDSS. Tie or tape a piece of string to your wood block so you can drag the block along a horizontal surface. Again, you need to be careful that the string and the tape to not affect the bottom surface of the block. Later, you will also want to add weights to the top of the block without affecting the string or bottom surface.

For your horizontal surface, the same surface you used for your inclined plane would be ideal, but the surface has to be horizontal. Don’t dismantle your inclined plane unless you are sure you won’t need to repeat any of the measurements from part I. You may instead choose to use a clean tabletop for your horizontal surface.

Step 1) Attach the string to the force sensor and use the force sensor to slowly drag the block (without additional weight) along the horizontal surface at constant speed. *Make sure the string remains horizontal.* Measure the force required to move the block at constant speed (the force might vary a bit so taking the average force over some distance may help). Record the mass of the block and the force required to move it at constant speed, as well as your uncertainty in the force.

Step 2) Repeat this experiment at least four more times for different masses of the block. Use the same block (with the same lower surface) in each case, but add weights to the top of the block to vary the mass. Record your data (including the data from Step 1).

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Step 3) What does the force required to move the block at constant speed tell us about the friction force between the block and the surface?

Step 4) How does the friction force seem to depend on the mass of the block? Come up with a description and try to find a way to test your description. (Hint: there are extra columns in the table above.)

Step 5) Discuss your results from Step 4 with your classmates and your instructor.

**Part III: Resolution**

Based on your results from Part I b, did you believe that changing the mass of the block changed the friction force between the block and the surface? Based on your results from Part II, do you believe that changing the mass of the block changes the friction force? Do these two results agree? If not, how can you resolve them? (Hint: they might *appear* to disagree at first, but a little thought should reveal that they don’t. Newton’s second law holds the key.)

Discuss your results with your classmates and your instructor. You should be able to write an explanation of how the results from part I b and part II really do agree with each other.

**And so what do you think determines which kid is the fastest getting down the slide?**