# GS104 Friction Lab

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## Purpose

The purpose of this lab is to test a variety of claims regarding friction forces and coefficients of friction.

## Equipment

| **You Procure** | **Lab Kit** |
|---|---|
| • horizontal surface (table, countertop, or floor)<br>• small, dense objects (coins, nails, washers, etc.)<br>• tape<br>• object of your choosing to replace cardboard box (optional) | • spring scale<br>• wood block<br>• cardboard box<br>• string |

## Important Terminology

- Measure: You collect data with tools and write it down. For example, you will measure weight and tension forces in this lab with your spring scale.
- Deduce: You use evidence and reason to determine something. For example, you will deduce friction and normal forces in this lab using Newton's first law.
- Calculate: You use other data and a formula such as multiplication or division. For example, you will calculate coefficients of friction using the formula for coefficient of friction.

## Experimental Procedures

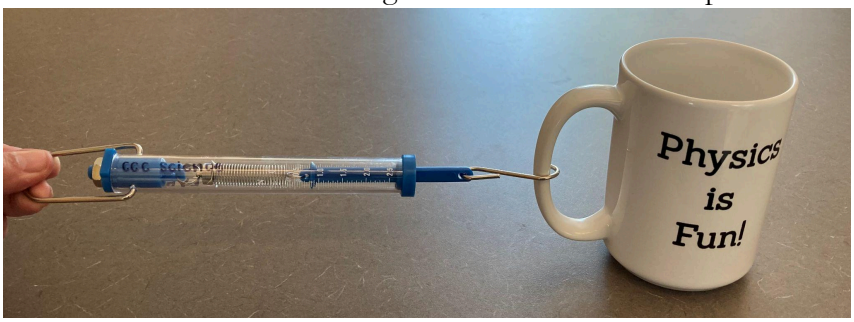
Be sure to post to the discussion board if you encounter a problem with this or any other lab.

1) Read the definitions of the terms above and complete the "stop to think" section of your report.
2) Tie string to the spring scale and the wood.
3) Weigh the wood by hanging it from the spring scale and **measuring the weight force in newtons** (not mass in grams). You will **measure the weight force**, not calculate it. No calculations are needed at this point.. Take a photo of this measurement.
4) Weigh the cardboard box. **Add weights to the box until the weight is the same as the wood.** Take a photo of your measurement once it is the same as the wood.

5) Place the wood on a horizontal surface with the broadest area down. The tape and string must not be on the bottom of the object. Or attach the spring scale to the hook on the object, if any.
6) Record a description of the object's name and material ("wood block", "cardboard box", "ceramic mug", etc.) and a description of the horizontal surface's name and material ("tile floor", wood table", etc.).
7) Hold only the spring scale and **make sure that the string is horizontal**. If you pull in a direction other than horizontal, then the analysis will be incorrect.
8) Pull on the spring scale until the object moves with constant velocity. Record the **measured** spring force in newtons. Take a video (one time only) of you pulling horizontally and the object moving with constant velocity and put it in your shared folder.
9) **Deduce** the net force on the object when it is moving with constant velocity, based on your answers to the stop to think questions.
10) **Deduce** both the friction force and the upward ("normal") force based on the other forces and the net force.
11) **Calculate** the coefficient of friction using the definition:

    coefficient of friction = friction force/normal force

12) Repeat the experiment with variations so that you complete the two tables. For trial 4, you may add the two weights instead of measuring the combination if the spring scale doesn't measure high enough.
13) To determine the static coefficient of friction (trial 6), repeat the experiment except that you will find the maximum spring force that will keep the object at rest instead of finding the spring force needed to move with constant velocity. Be sure to very slowly increase the spring force until the object begins to move.
14) Evaluate the evidence according to the criteria in the template below.




The above photo shows a spring force of about 0.8 N on the mug.

Do not include the above instructions in your report.

GS104 Friction Data and Calculations
Name _____

**Stop to Think (Newton's First Law)**

1) Write down Newton's first law.

2) What is the net force on an object that remains at rest?

3) What is the net force on an object moving with a velocity that remains constant?

**Stop to Think (Vocabulary)**

4) In the box next to each statement, write down the verb describing the activity ("measure", "deduce", or "calculate").

| | |
|---|---|
| A person uses a meter stick to determine the length of a board. | |
| A person multiplies mass times acceleration to determine the net force on an object. | |
| A person observes an object remaining at rest and determines the net force upon it. | |
| A person knows all of the individual forces on an object and uses them to determine the net force. | |
| A person uses the formula for weight force (W = m*g) to determine a weight force. | |
| A person steps on a scale to determine the weight force upon them. | |
| A person uses a stopwatch to determine the time it takes someone to run a certain distance. | |

5) Write or sign your name below to indicate that you understand the distinctions among the terms "measure", "deduce", and "calculate" and that you will apply them in this lab.

6) Look up the Latin phrase "ceteris paribus" and write it down. Cite your source.

7) Write or sign your name below to indicate that you understand the meaning of "ceteris paribus" and will use the concept in this lab.

8) Write or sign your name below to indicate that you plan to follow step 3 of the lab instructions in its entirety. So the weights of the two objects will be the same.

9) Write or sign your name below to indicate that you will very carefully read and obey which object (object 2) goes on top in trial 4. You will put object 1 on the bottom.

## Data Tables

Note: Do not put any units in the data tables. Units are already listed in the first column.

| **Broad side down, kinetic** | **Object 1 (trial #1)** | **Object 1 faster (trial #2)** | **Object 2 (trial #3)** | **Object 1 with Object 2 on top (trial #4)** |
|---|---|---|---|---|
| Horizontal surface description (ex: kitchen counter) | | | | |
| Material of the horizontal surface (ex: granite) | | | | |
| Object description (ex: block) | | | | |
| **Single** material of the object in contact with the horizontal surface (ex: wood) | | | | |
| **Measured** strength of weight force by Earth down (N) | | | | |
| **Measured** strength of spring force by scale to right (N) | | | | |
| **Deduced** net force (N) | | | | |
| **Deduced** strength of normal force by surface up (N) | | | | |
| **Deduced** strength of friction force by surface to left (N) | | | | |
| **Calculated** coefficient of friction (no units) | | | | |
| **Single** variable you changed compared to trial #1 | N/A | speed | | |

| | **Narrow side down, kinetic, object 1 (trial #5)** | **Broad side down, static, object 1 (trial #6)** |
|---|---|---|
| Horizontal surface description | | |
| Material of the horizontal surface | | |
| Object description | | |
| Material of the object in contact with the horizontal surface | | |
| **Measured** weight force by Earth down (N) | | |
| **Measured** spring force by scale to right (N) | | |
| **Deduced** net force (N) | | |
| **Deduced** normal force by surface up (N) | | |
| **Deduced** friction force by surface to left (N) | | |
| **Calculated** coefficient of friction (no units) | | |
| **Single** variable you changed compared to trial #1 | | |

**Explanations and Showing Work**

Explain how you deduced the net forces.

Explain how you deduced the strengths of the friction and normal forces.

Provide one detailed example of one of your calculations of a coefficient of friction (symbolic or word formula, numbers in the equation, and answer as usual).

Provide a link to a video in your shared folder with you pulling horizontally and the object moving with constant velocity.

## Evaluating Experimental Evidence

For **each** of the following six evaluations, you must include the following:

a) The trial numbers that you are comparing **and** an explanation of why you chose these trials such as "I am comparing trial 2 to trial 1 because they have different speeds, but other things are equal". **The trials must be ceteris paribus**.
b) The data from the trials that you are comparing such as "Trial 2 had a coefficient of friction of 0.25 while trial 1 had a coefficient of friction of 0.15".
c) A comparison of the two numbers such as "0.25 is significantly bigger than 0.15" or "0.16 is very similar to 0.17".
d) A statement of whether or not your evidence supports the claim such as "My experiment does not support the claim that the coefficient of friction remains constant with a change in speed, other things equal".

1) Evaluate the claim that the static coefficient of friction is greater than the kinetic coefficient of friction for a given pair of substances, other things equal.

2) Evaluate the claim that the kinetic coefficient of friction is different for different pairs of materials, other things equal (to the extent possible; you might have a different area as well).

3) Evaluate the claim that the kinetic coefficient of friction remains constant with a change in speed, other things equal.

4) Evaluate the claim that the kinetic coefficient of friction remains constant with a change in contact area for a given pair of substances, other things equal.

5) Evaluate the claim that the kinetic coefficient of friction will remain constant for a given pair of substances with an increase in mass or weight, other things equal.

6) Evaluate the claim that the **force** (not the coefficient) of kinetic friction will increase for a given pair of substances with an increase in mass/weight, other things equal.

In your above evaluations, focus on experimental evidence, not your feelings or purely theoretical considerations.

## Discussion

Copy and paste your lab discussion below (including the time and date):

## Academic Honesty

Report the names of anyone besides the instructor who assisted you in this work and report how they assisted you. Or state that you did not have any human assistance.

Report any resources (besides a calculator) you used outside of those provided on Canvas, such as apps or websites, and report how you used them. Or state that you did not use any such resources.

## Submitting Work

Create a single pdf and upload your report to Canvas. Do not include the instructions from the first two pages.