FRICTION

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Va. SOL:

PH.1 The student will plan and conduct investigations in which
- a) the components of a system are defined;
- b) instruments are selected and used to extend observations and measurements of mass, volume, temperature, heat exchange, energy transformations, motion, fields, and electric charge;
- c) information is recorded and presented in an organized format;
- d) metric units are used in all measurements and calculations;
- e) the limitations of the experimental apparatus and design are recognized;
- f) the limitations of measured quantities are recognized through the appropriate use of significant figures or error ranges;
- g) data gathered from non-SI instruments are incorporated through appropriate conversions; and
- h) appropriate technology including computers, graphing calculators, and probeware, is used for gathering and analyzing data and communicating results.

PH.2 The student will investigate and understand how to analyze and interpret data. Key concepts include
- a) a description of a physical problem is translated into a mathematical statement in order to find a solution;
- b) relationships between physical quantities are determined using the shape of a curve passing through experimentally obtained data;
- c) the slope of a linear relationship is calculated and includes appropriate units;
- d) interpolated, extrapolated, and analyzed trends are used to make predictions; and
- e) analysis of systems employs vector quantities utilizing trigonometric and graphical methods.

PH.3 The student will investigate and understand how to demonstrate scientific reasoning and logic. Key concepts include
- a) analysis of scientific sources to develop and refine research hypotheses;
- b) analysis of how science explains and predicts relationships;
- c) evaluation of evidence for scientific theories;
- d) examination of how new discoveries result in modification of existing theories or establishment of new paradigms; and
- e) construction and defense of a scientific viewpoint (the nature of science).

PH.4 The student will investigate and understand how applications of physics affect the world. Key concepts include
- a) examples from the real world; and
- b) exploration of the roles and contributions of science and technology.

Topic/Concept

Static and kinetic friction and coefficient of friction

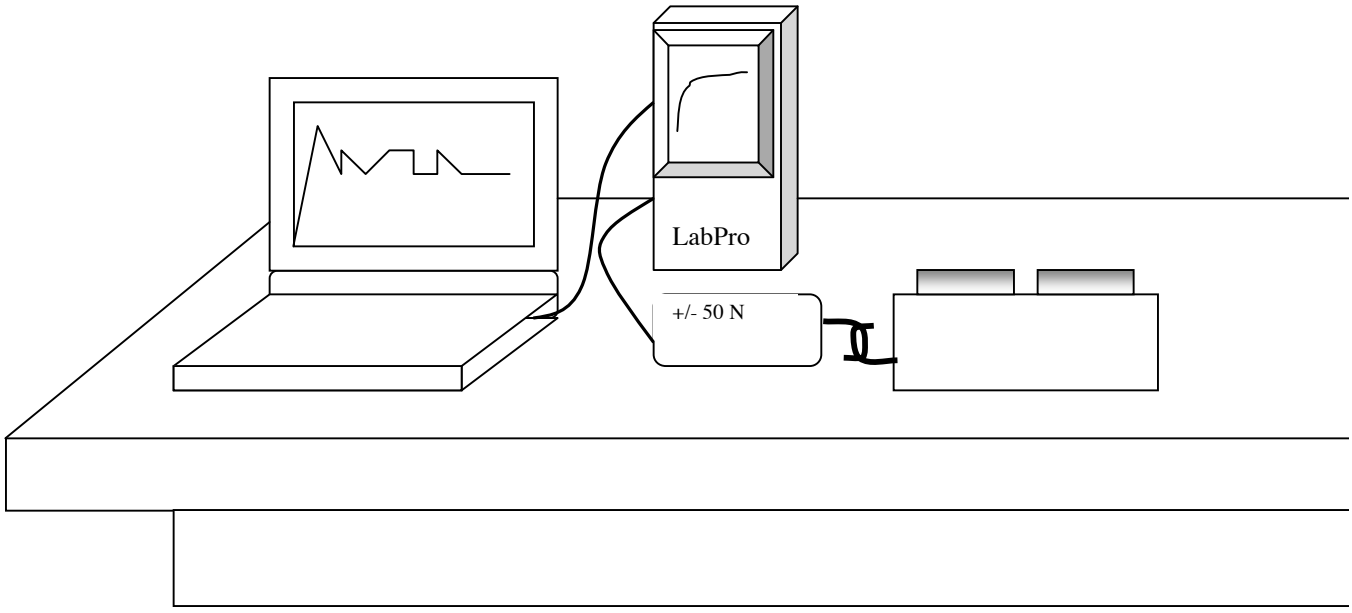
Materials

Included in lab write up

Safety Considerations

Large masses – 5 kg in use

Presentation



A wooden block is dragged with a Vernier force probe in order to measure the force of friction. The kinetic and static coefficients of friction are determined and it is observed that μ does not depend on weight of object and that static friction is greater than kinetic.

Frictions

Introduction

When students begin to study Newton's 1st law the idea of "an object in motion staying in motion" is a difficult concept. This is due to our every day experience of seeing objects that are set in motion grinding to a halt if we don't keep pushing them. This acceleration (remember, slowing down is accel. also) is caused by friction. When students begin to study Newton's 2nd law the presence of friction as an additional force also can cause some confusion. Since in our daily experience friction is an unavoidable fact of life it is necessary to understand how it operates. There are three basic types of friction; rolling friction, sliding friction, and static friction. Rolling friction as you might guess concerns objects that roll or have wheels. (a cart rolling across a table) Sliding friction concerns objects that have no wheels moving across another surface. (a book sliding across a table) Static friction is the friction that exists between two surfaces that are not moving relative to each other. (a book that is at rest on a table and is being pushed by your hand but is not sliding yet)

All three types of friction can be described by a term called the coefficient of friction. This term has the symbol μ which is a Greek letter and is pronounced "mu". It is a ratio of the frictional force on an object to the support force provided by the surface on which it rests. This support force is called the normal force and is always perpendicular to the surface on which the object rests. The equation then is

$$\mu = \frac{F_f}{F_n}$$

Equipment

Wooden block and four 1.0 kg masses
LabPro
Laptop with LoggerPro
+/- 50 N force probe
DIN adaptor

Procedure

Hook it all up. Teacher will demonstrate set up. The force probe needs an adaptor to plug into the LabPro. Make sure the force probe is switched into the +/- 50 N mode.

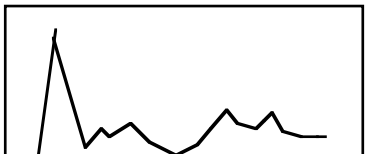
The force probe must be calibrated. To do this follow the prompts on the Lab WhiteBoard. Use 0 N as one standard. Hang 2 kg on it and use the correct weight of 2 kg as the second standard.

After calibration you are ready to collect data.

Experiment Procedure

Put your cart on its back so the wheels don't work.

Choose a time for your experiment that will allow you to gradually increase the pulling force until the cart begins to slide and then pull it with a constant velocity for a little while.



√ for a good trial. If you have done it well, your graph will look something like this

Use Logger-Pro features to analyze the data to determine the following things:
1- the maximum amount of friction
2 - the average amount of friction while the block is sliding.
3 - the uncertainty in the sliding friction.
Conduct 3 trials of each mass and record the data in an organized data table.

Evaluation

For each of the following questions, site evidence from your data that supports your answer. Include uncertainty in your thinking.

1. Does the force of sliding friction change as weight is increased?

2. Does the value of μsliding change as weight is increased?

3. Does the force of static friction change as weight is increased?

4. Does the value of μstatic change as weight is increased?

5. For an object of a given weight which type of friction is the greatest?

6. Create a graph of Sliding Friction Vs Normal Force. Include error bars for the Sliding Friciton. What does the shape of the graph tell you and what does the slope tell you?

Teacher Tips Regarding Lab

I use this lab to teach the physics of friction and to enhance the treatment of error beyond just significant figures use. Friction has become the focus of an extension I do with James Madison Physics Department where my students investigate friction on the nano-scale.

Sources & References