Physics 250 Laboratory:
Friction, Work & Energy-Mythbusting[1] Edition
(Forces)

Score: _____ Section #:_____

Name:_____

Name:_____

Name: _____

Lab-Specific Goals:

- To experimentally test some "myths" about friction, work and energy. You will need to design and execute experiments to test these myths (or do this measurement) and then analyze your results to determine if these myths are false ("busted"), true ("confirmed"), or maybe possible ("plausible").

Equipment List:

- Board with friction for sliding block along
- Photogate system (2 gates)
- Rectangular block
- Masses to add to block
- Thick dowel
- Poster putty for attaching dowel to block
- Meter stick

Introduction and Pre-Lab Questions:

An object sliding across the floor or a table has a kinetic friction force acting on it from the surface. Draw a free-body diagram for the object (let's say it's moving to the right).

[1] Inspired by the Discover Channel show "Mythbusters", which has no relationship to (or responsibility for) this laboratory or the Penn State physics department.

What's the *formula* for the magnitude of the kinetic friction force f_k?

What's the *formula* for the work done by kinetic friction if the object moves a distance d?

If the object has a mass of m = 2 kg and the coefficient of kinetic friction is $\mu_k = 0.35$, what is the magnitude of the kinetic friction force?

What's the work done by this frictional force as the object moves to the right 2 meters?

What is the speed of the object after moving 2 meters if its initial speed was 10 m/s?

What is the speed of the object after moving an addition 2 meters (that is, 4 meters total)?

In this experiment, you will test four "myths" about friction, work & energy. For each one, you will design an experiment and then analyze your results to determine if the "myth" is confirmed, busted, or plausible.

The four "myths" you will be testing about friction, work & energy are:

1) For an object sliding across a surface with friction: if you double its initial velocity you *quadruple* the distance it travels before stopping.
2) For an object sliding across a surface with friction: if you double the weight of the object, it will stop in half the distance (for the same initial velocity).
3) If you double the surface area (leaving everything else unchanged) an object will go half as far before stopping.
4) The magnitude of the kinetic friction force does *not* depend on the speed of the object.

For each "myth", you need to:

(1) Develop and carefully describe a procedure you will use to test the "myth". (None of the myths should require a complex setup or procedure.) Note: one way a myth can be busted is by demonstration of a counter-example, so you may not need to collect numerical data to bust/confirm every myth.
(2) Collect data and record in a data table (if appropriate). You should only need a few runs for each myth. The data may be numerical and/or observations you have made during your experiments.
(3) Analyze your data and observations to determine whether the "myth" is "busted", "confirmed" or "plausible". Carefully explain your reasoning based on your data/observations for your statement about each myth.

Note: even if a myth talks about doubling a quantity, you can still test this myth even if you can't exactly double the quantity. *Focus on the relationship between the quantities:* is it predicting a linear relationship (doubling X doubles Y), a quadratic relationship (doubling X quadruples Y), an inverse relationship (doubling X halves Y), a square root relationship (quadrupling X doubles Y), or some other relationship? A graph provides an excellent way of examining the relationship between your variables.

For myths 1-3, you must graph your data in a way that is meaningful for the experiment using the graph paper at the end of the lab report and then interpret what the graph says about the "myth".

- **You will use the same graph paper for all three myths so think about what variables you would want to graph.**
- **Use different symbols/markers for data you collected for each myth so you can distinguish them.**
- **On your graph, you must draw a dotted line showing what the myth predicts the graph should look like. Then discuss whether the data matches the prediction of the myth. (Be sure to label the predicted lines by myth.)**

When you are done with all four "myths", you will record your answers on the class answer sheet and the front of the room.

Myth #1: For an object sliding across a surface with friction: if you double its initial velocity you quadruple the distance it travels before stopping.

This myth is: _____ (Busted, Confirmed, Plausible)

In the space below, describe the procedure you will use to test this myth. Include a sketch of your experimental apparatus (e.g., where the glider will start, where the photogate(s) will be positioned, etc.). Be sure to indicate what measurements you will make and what calculations you will do.

In this space, make a data table for your measurements and calculations (if appropriate) or record your observations in a systematic way. *Be sure to make several "runs" for each experiment!*

In the space below, describe your data analysis and what conclusion you came to based on your analysis.

Myth #2: For an object sliding across a surface with friction: if you double the weight of the object, it will stop in half the distance (for the same initial velocity).

This myth is: _____ (Busted, Confirmed, Plausible)

In the space below, describe the procedure you will use to test this myth. Include a sketch of your experimental apparatus (e.g., where the glider will start, where the photogate(s) will be positioned, etc.). Be sure to indicate what measurements you will make and what calculations you will do.

In this space, make a data table for your measurements and calculations (if appropriate) or record your observations in a systematic way. *Be sure to make several "runs" for each experiment!*

In the space below, describe your data analysis and what conclusion you came to based on your analysis.

Myth #3: If you double the surface area (leaving everything else unchanged) and an object will go half as far.

This myth is: _____ (Busted, Confirmed, Plausible)

In the space below, describe the procedure you will use to test this myth. Include a sketch of your experimental apparatus (e.g., where the glider will start, where the photogate(s) will be positioned, etc.). Be sure to indicate what measurements you will make and what calculations you will do.

In this space, make a data table for your measurements and calculations (if appropriate) or record your observations in a systematic way. *Be sure to make several "runs" for each experiment!*

In the space below, describe your data analysis and what conclusion you came to based on your analysis.

Myth #4: The magnitude of the kinetic friction force does not depend on the speed of the object

This myth is: _____ (Busted, Confirmed, Plausible)

In the space below, describe the procedure you will use to test this myth. Include a sketch of your experimental apparatus (e.g., where the glider will start, where the photogate(s) will be positioned, etc.). Be sure to indicate what measurements you will make and what calculations you will do.

In this space, make a data table for your measurements and calculations (if appropriate) or record your observations in a systematic way. *Be sure to make several "runs" for each experiment!*

In the space below, describe your data analysis and what conclusion you came to based on your analysis.

Discussion:

For each of the myths addressed above, give an argument from what we know about friction, work and energy for why it is correct ("confirmed") or incorrect ("busted"):

1) For an object sliding across a surface with friction: if you double its initial velocity you quadruple the distance it travels before stopping.

2) For an object sliding across a surface with friction: if you double the weight of the object, it will stop in half the distance (for the same initial velocity).

3) If you double the surface area (leaving everything else unchanged) an object will go half as far.

4) The magnitude of the kinetic friction force does not depend on the speed of the object.

Graph for Myths #1-3

Be sure to label the graph and use the graph in your data analysis & discussion for these myths.

Can you argue whether or not the point (0,0) must be on the graph?

Graph for Myths #1-3 (in case you need to start over)

Be sure to label the graph and use the graph in your data analysis & discussion for these myths.

Can you argue whether or not the point (0,0) must be on the graph?

Appendix: Using Photogates

PULSE MODE (2 photogates): This mode measures the time between when one photogate is triggered and when the other photogate is triggered. It is good for finding the time the glider takes to get from one gate to another and thus finding the average velocity in that interval. (Have the memory switch to off.)

GATE MODE (1 or 2 photogates): This mode measures the time that one of the photogates is blocked. It is good for finding the time it takes the glider's "sail" (10 cm-long) to pass through the gate and thus in finding the velocity of the glider at the point on the track.

Collecting multiple time measurements in GATE mode:

1. Flip the memory switch to "On".
2. Release / push the glider (as appropriate for your experiment) so that it passes through the photogates.
3. The time displayed on the screen is the time that the first photogate triggered was blocked. (We'll call that Δt_1.)
4. Toggle the memory switch to "Read" and another time will be displayed. This time is the total time that the photogates were blocked, or $\Delta t_1 + \Delta t_2$, where Δt_2 is the time the second photogate triggered was blocked. (It can also be used for a single photogate that is blocked twice.)

Always press RESET between readings to zero the timer.