PHYS 100 EXPERIMENT 5 (week 6)
Friction

Name: _____ Student #: _____ Section: ____ Date: _____

Overview:
- *Previous homework (5 min)*
- *Introduction (5 min)*
- *Planning (10 min)*
- *Measurements (20 min)*
- *Analysis (25 min)*
- *Summary (15 min)*

Topic:

The lab today has three main goals:
1. To understand how static friction works.
2. To see how experiments help us learn about nature.
3. To learn to draw and interpret scatter plots.

Introduction (5 min, entire class)

What's interesting about friction? It seems that friction only comes to mind on special occasions, for example when friction is very low (skating, skiing, hitting an ice patch with your bike), or when friction is large (when moving heavy furniture, for example).

However, almost all motion is affected by friction. You have to go to sophisticated technical solutions to avoid it (like maglev trains; see http://www.youtube.com/watch?v=Ws6AAhTw7RA for an example, and then google for more – fascinating!).
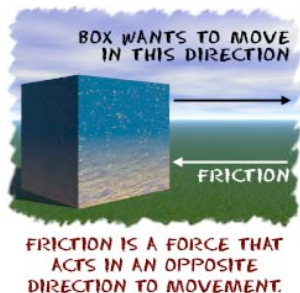
Imagine that you are trying to pull a heavy box, and yet the box does not move. Why is that? Static friction is friction between two solid objects that are not moving relative to each other. In order to overcome the static friction, you should apply more force. Static friction has a maximum. When you apply enough force, the box would start sliding on the floor.

☞**Clicker 1:** The mass of each of the following boxes is 70kg. If one person can push a single box (a), but not more than that, how many people are required to push three boxes (b)?

(a)   (b)
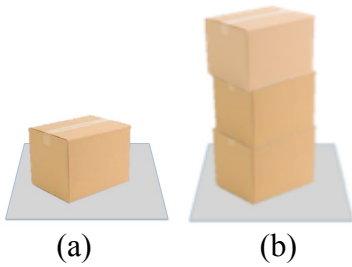
  A. More than 1 but less than 3.
  B. 3 people.
  C. More than 3 but less than 9.
  D. 9 people.
  E. Depending on the friction.

Problem set up

Today we will explore the maximum static friction (that is, the maximum friction before the object begins moving).

Your research question is the following: **What is the dependency of static friction on mass?**

Note that we only care about static friction. That is, we care when the block starts to move – not what happens to it once it is already moving.

Tasks

Task 1: Planning (10 min, pairs)

See what materials you have. Experiment with them. Plan your experiment.
Start the software by choosing the "Lab Exam Force" icon on your desktop.
Calibrate the force probes by clicking the "as zero" button, next to "Collect".

The following questions will help you design your measurements. You can modify
your answers once you gathered some data.

- The research question asks about the effect of mass on friction. How can you
  change the mass of the block?

- How many different masses do you plan to test? Why?

- How many times will you repeat each measurement?

Task 2: Measurements (25 minutes, pairs)

Collect data to help you answer the research question.
Write down your measurements in the space provided below.
Remember to document your experimental setup. What materials did you use, and in what manner? You will need this information when you begin analyzing your data.

Task 3: Analysis (25 min, pairs)

Organize your data. Remember that graphs are a good way to show large amounts of data.
Scatter plots seem especially relevant to plot this data, as they show dependency of one variable on another. Here is one way to plot friction vs. mass:

```
Minimum    |
force to   |
move the   |
block      |
           |_____
              Mass of
               block
```
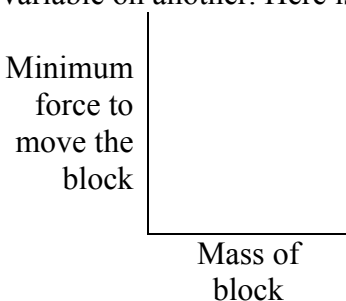
First, plot the raw values that you measured.

Using a ruler, make a straight line that captures the trend of your data. This line describes the function of friction vs. mass.

By the end of this task you should have a graph of force vs. mass with roughly 10 data points (one for each experimental setup). You should also have a single trendline that matches this data.

Use the graph to answer the research question: What is the dependency of friction on mass? Justify your answer using your data.
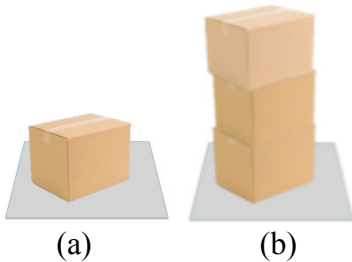
Bring the lab with you next week, as you will be measuring these graphs!!!
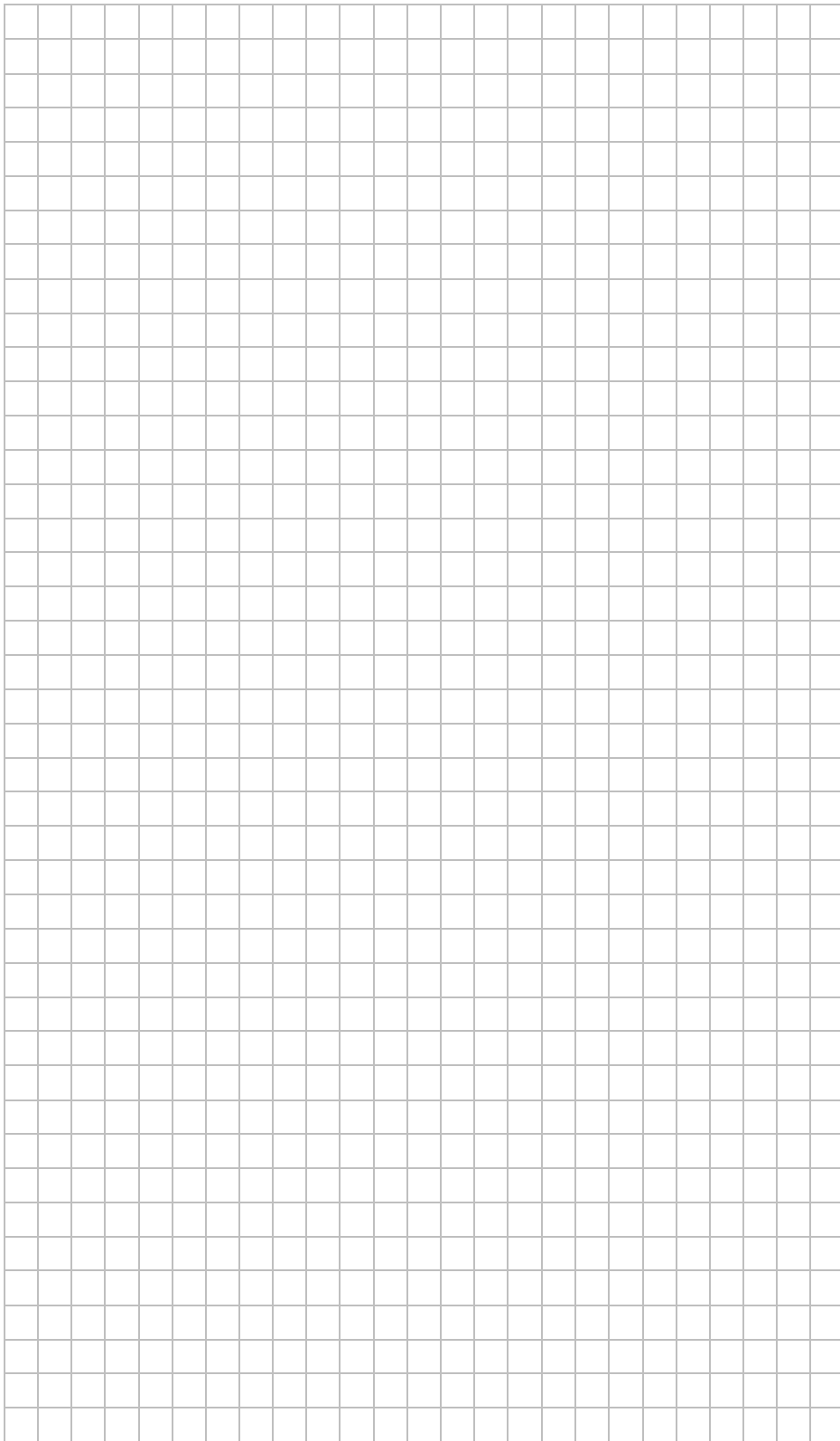
Task 3: Summary (10 min, entire class)

Let us revisit the original question:

☞**Clicker 2:** The mass of each of the following boxes is 70kg. If one person can push a single box (a), but not more than that, how many people are required to push three boxes (b)?

(a)   (b)

    A. More than 1 but less than 3.
    B. 3 people.
    C. More than 3 but less than 9.
    D. 9 people.
    E. Depending on the friction.

☞**Clicker 3:** Which of the following scatter plots shows the strongest dependency of Y on X?
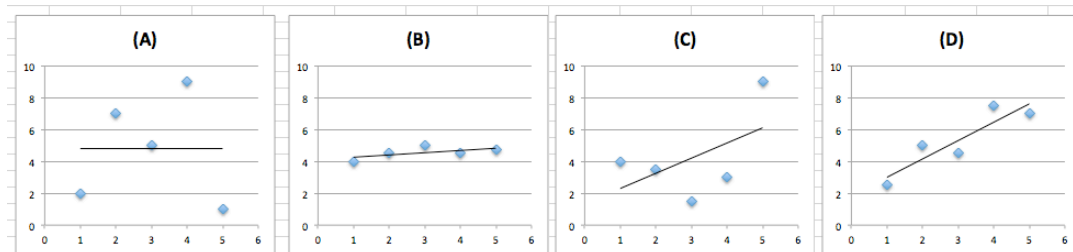
☞**Clicker 4:** Why did we plot raw data and not means?

    A. Plotting means would have taken too long due to additional calculations.
    B. Without raw data we cannot see the distribution in each experimental set-up.
    C. Plotting means is mathematically meaningless since there are too few points for each experimental setup.
    D. To practice plotting more points.

PHYS 100 Homework 5 (for week 7)
Static Friction Coefficient

Name: _____ Student #: _____ Section: _____ Date: _____

Using Excel

In today's homework you will use Excel to draw a scatter plot and make a trend line. The next page gives you instruction for one version of excel. If you use a different version of Excel or Open Office, google the relevant instructions ("scatter plot with trendline in excel" seem to be a good search term).

Submit (limited to 1 page, double sided):
1. Your name, student ID, and section.
2. A snapshot of the excel table with your raw data (a snapshot is a picture of the computer screen).
3. A snapshot of your scatter plot with the trendline. Make sure that the snapshot is large enough, as you will use it in your measurements next week.
4. Ask excel to show the equation of the linear trendlines (for simplicity, we focus on linear relationships for now). Given that the formula for static friction is $F = \mu N$ (with F being force, μ the static friction coefficient, and N being the normal force), can you use your graph to calculate the coefficient of friction? Explain your answer.
   a. Hint 1: Remember that a line equation is $y=ax+b$, and a is the slope.
   b. Hint 2: Remember to convert from mass (that you measured) to the normal force ($N=mg$, or roughly 10m, on a horizontal plane).
5. Copy and paste the rubric table below to your HW sheet. You can also download a jpg from UBC Connect / P100 / Labs.

Remember to bring the HW, as well as the graphs you plotted by hand at the lab, to the next lab.

Rubric

	Sufficient (✓)	Lacking (✓̸)	Insufficient (x)
Raw data is complete, with titles and units (in the title only)			
Scatter plot is valid and shows raw data			
Trendline is shown with the line equation			
Estimate of coefficient of friction is based on the graph and well justified.			

Making scatterplots in Microsoft Excel:

1. Type data into spreadsheet

2. Highlight data and under the insert menu, select 'Scatter' (ignore the uncertainties shown below – we haven't calculated them yet for this data).


3. Select the layout you want in the 'Chart layout' menu. Hiding the horizontal grid lines is often a good idea since it clutters up the plot
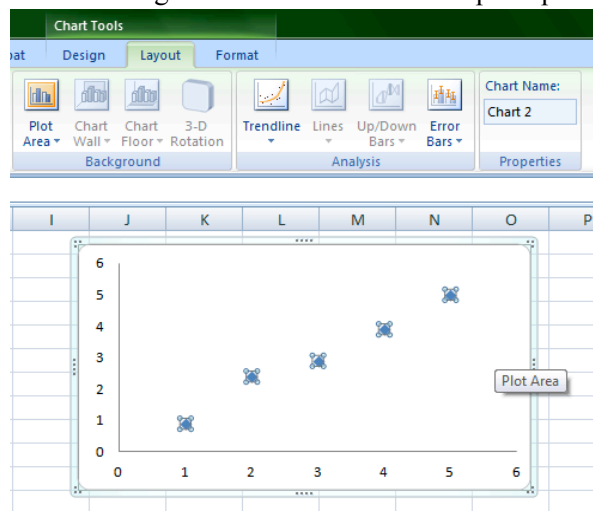
4. To add a trendline, click on the plot and under the Layout tab, click 'Trendline' (again, ignore the uncertainties that are shown below – we haven't calculated these yet).
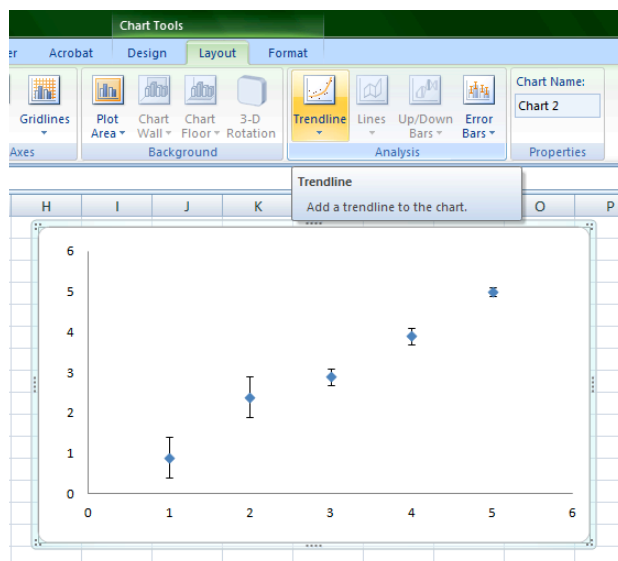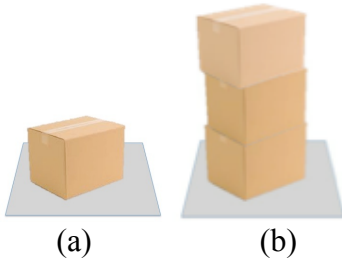

5. Choose a fit from the list or select 'More trendline options' for more fit types
6. To view the equation for the line of best fit, click on 'More trendline options' and click 'Display equation on chart'
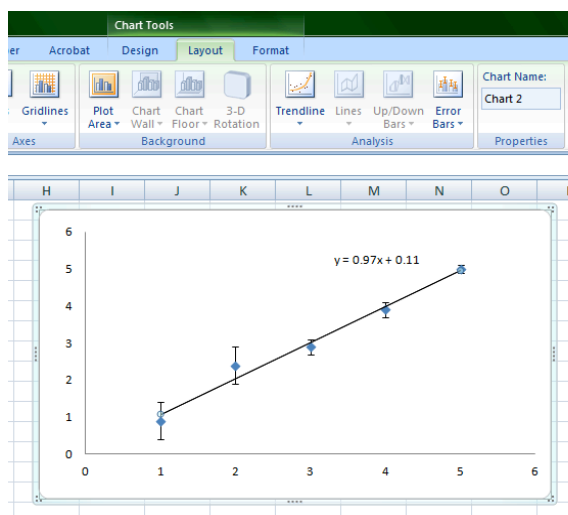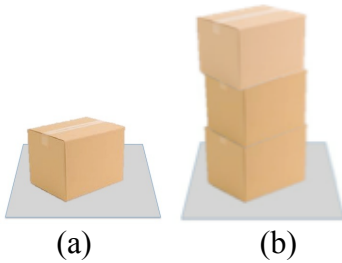
Clicker resource page

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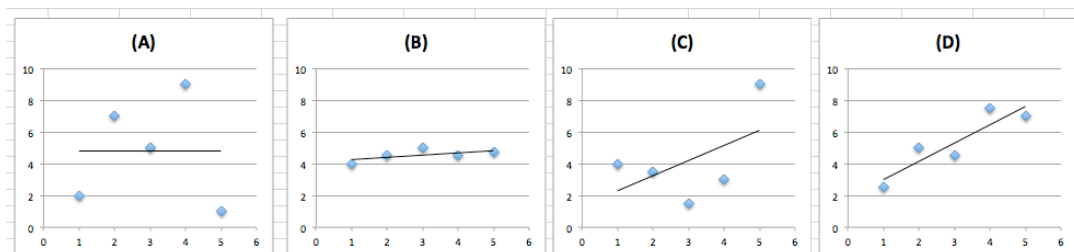

    (a)   (b)

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