PHYS 103 LAB 4 FORCES PART 1

INTRODUCTION

In this laboratory you will investigate Hooke's Law. You will use **Force Sensors** and **spring scales** to measure *forces*. You will tabulate and graph your results using **Microsoft Excel**.

THEORY

One of the *forces* we continuously encounter in our daily experience is the *gravitational* pull that the Earth exerts on all objects. It is that force that makes the objects fall down just as the basketball did in our last experiment. We call this force the *weight* of an object and we'll denote it with the symbol $\boldsymbol{F_G}$. The *weight* of an object is equal to its *mass* times the *gravitational acceleration* $\boldsymbol{g}$ and its always directed downward (just as $\boldsymbol{g}$). We write:

$$\boldsymbol{F_g} = m\boldsymbol{g}. \tag{1}$$

IMPORTANT: *Weight* and *mass* are two different physical quantities, but are easily confused. In old English unit system you usually purchase things like flour by *weight* (pound is a unit of *force* in old English), while in SI system you'd purchase flour by *mass* (kilogram is a unit of *mass* in SI system).

In part 1 of this experiment you will use **Force Sensors** to measure the weight of the masses suspended from them and, thus, test equation 1.

In part 2 of this lab you will use **spring scales** to measure *forces*. These **scales** work by measuring how much *force* it takes to stretch the spring a particular amount. Springs work according to Hooke's law which says that the *force* required to stretch the spring by *distance* of x is directly proportional to this *distance* x. Specifically,

$$\boldsymbol{F} = k\boldsymbol{x}, \tag{2}$$

where k is a so called *spring constant*, particular to the individual spring. The larger the value of the *spring constant* the stiffer the spring is and the more *force* is needed to stretch it a certain amount.

NOTE: Although **spring scales** are in fact measuring the *weight* they can calibrated in terms of *mass* and show grams and/or kilograms, which only adds to the confusion. When you use **spring scales** to measure *forces* you should use the scale in Newtons.

PROCEDURE

PART 1 WEIGHT

1. Physically connect the **Force Sensor** to the analog channel A of the **Interface Box**.

2. Open **Data Studio** and **'Create Experiment'**.

3. From the list of sensors in the **'Experiment Setup'** window select **'Force Sensor'** and then drag the **'Force Sensor'** icon over the analog channel A on the image of the **Interface Box**. Double–click on the **'Force Sensor'** icon, select **'Calibration'** tab, and set the sensitivity to low. Set the sample rate to 100 Hz. The measured *force* will be the *force* applied to the metal hook on the bottom of the **Force Sensor**.

4. Hang the **Force Sensor** on a stand.

5. In **Data Studio** create a graph of *force* vs. *time*.

6. Press the **'START'** button on the top of the **Data Studio** screen to see if the **Force Sensor** is calibrated to zero. To reset it press **Tare** button on the **Force Sensor**. This is something you may need to reset throughout the lab before each measurement. **'STOP'** the run and delete the data.

7. Assemble the following masses: 100 g, two 200 grams, 500 g and 1 kg.

8. Press the **'START'** button on the top of the **Data Studio** screen and double check the tare. Continue collecting data while you hang a 100 g *mass* on the **Force Sensor**. Steady it so it does not swing and let the **Force Sensor** collect the data for a few seconds. **'STOP'** the run.

9. In the *force* versus *time* graph select the data corresponding to a time interval when the reading of the **Force Sensor** is the most stable.

10. Find the mean value of the force for the selected data. To do that press **'Σ'** button on the tool bar of your graph window.

11. <u>Record the reading in an Excel table similar to table 1:</u>

Table 1.

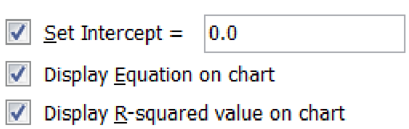
Mass (kg)	Force (N)
0.1	
0.2	
0.3	
0.4	
0.5	
0.7	
1	

12. Repeat steps 8 - 11 for the following masses: 200 g, 300 g, 400 g, 500 g, 600 g, 700 g, 800 g, 900 g, and 1 kg. Be careful and make sure not to drop the masses on your toes.

12. In Excel make a graph of *force* versus *mass*. To do this use the mouse to select the data in the table click insert tab on the top toolbar and from the list of charts choose an **'XY (Scatter)'** chart with the option on the drop down menu where only the data is shown (no lines).

Under Chart Tools, choose layout tab. This will show you the menu that allows you to label the axis. Do not forget to include units.

13. Does the data look linear? If so, put a linear trendline through it (that's what **Excel** calls fitting). To do that right click on the data in the graph and from the dropdown menu choose "Add trendline". A "Format trendline" window will open and it will have a default setting for the linear trendline selected. Check three boxes on the bottom:



Then click "Close" button. On the graph you should now see the fitted line as well as a box with the equation for the fitted line and parameter R^2.

14. <u>Is your data linear?</u> (look for the R^2 value).

15. <u>Why did we choose to set the intercept to zero?</u>

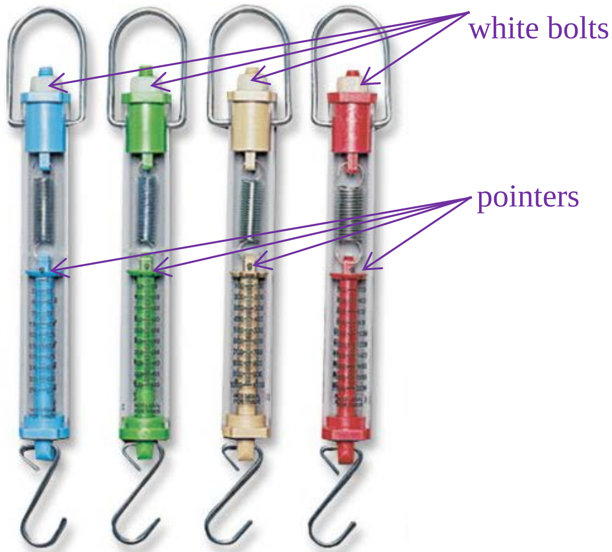
16. <u>What physical quantity does the slope of your graph represent? Discuss what it specifically means.</u>

17. Print your table and graph. Make sure it all fits on one page.

NOTE: You will be using Force Sensors frequently in this lab. They often lose their calibration so each time check if they work properly by hanging a known mass (like 0.5 kg) on them and checking that the reading is correct. Let this become part of your routine whenever you use Force Sensors.

PART 2 HOOKE'S LAW

1. Pick up each of the four spring scales. From the set, pick up the blue **spring scale**.



2. Hold a **spring scale** vertically and observe the *position* of the pointer. If it is not at zero calibrate your scale by by turning the white bolt at the top of the scale.

3. Pick up the blue spring scale, hang it from the stand.

4. Using a ruler make five – eight measurements of the distance that the spring stretches when a weight is hung from it and record the data in the table below. Select appropriate masses for your scale so that you span the whole rage over which the scale works. **Take good care not to drop the weights on your or your classmates' toes!!!!**

5. For each measurement record the distance that the spring stretches and the magnitude of the force stretching the scale in a **Microsoft Excel** table similar to table 2.

Table 2.

Blue scale		Green scale		Brown scale		Red scale	
The distance the spring stretched (cm)	The magnitude of the force that stretched the spring (N)	The distance the spring stretched (cm)	The magnitude of the force that stretched the spring (N)	The distance the spring stretched (cm)	The magnitude of the force that stretched the spring (N)	The distance the spring stretched (cm)	The magnitude of the force that stretched the spring (N)

6. Plot the magnitude of the force that stretched the spring versus the distance the spring stretched using **Microsoft Excel.** All four sets of data for our four springs need to be ploted on a single graph. Do not forget to label the axis and include units. If needed adjust the scale on the axis so that the data are spaced over the whole graph.

7. Fit each data set with a linear trendline. Select **'Options'** tab and check the boxes **'Set intercept = 0'**, **'Display Equation On Chart'** and the **'Display R-squared value on chart'**.

8. Summarize the outcome in a table similar to table 3.

Table 3.

	Blue scale	**Green scale**	**Brown scale**	**Red scale**
k (N/cm)				
R^2				

9. Is your data linear? (look for the R^2 values).

10. Why did we choose to set the intercept to zero?

11. What physical quantity do the slopes of your graphs represent? Discuss what it specifically means.

12. For the four **spring scales**: how do their *spring constants* compare? How do the graphs compare? Which spring requires more force to stretch by the same distance? Why?

13. Print your table and graph. Make sure they all fit on one page.

PART 3 MYSTERY SPRINGS – EXTRA CREDIT (UP TO 10 POINTS)

Use equipment provided to establish the spring constants for the mystery springs. Your grade will be based on the quality of data and its analysis. Describe what you did and what was the outcome of your experiment.

Print all your data, graphs, and tables, and attach them to your report.
Whenever possible SAVE PAPER.
Delete your files from the computer.
Disconnect all equipment, close all applications, and log off your PC.
DO NOT TURN THE COMPUTER OFF.
Make sure you leave the classroom as you found it.

LAB 4 REPORT

Group name:...

Partners names:...

....

....

INTRODUCTION:

DATA PRESENTATION:

PART 1

14.

15.

16.

Part 2

9.

10.

11.

12.

PART 3 (Describe what you did and what was the outcome of your experiment.)

REMINDERS: Include units.
Make sure to attach all your data and graphs. No data = No credit
Please do not hand in the manual, just the report.

CONCLUSION: