PHYS 103 LAB 6 WORK AND ENERGY

INTRODUCTION

In this lab you will study the concept of *work*. You will use the data from the last experiment as well as a newly collected data collected with a modified setup to find the work done on the cart by variety of pulling and pushing forces. You will use a **Force Sensors** to measure *forces* and a **Motion Sensor** to find the displacements. You will tabulate your results using **Microsoft Excel**.

THEORY

The work done by a constant force does in an object by a distance Δd (provided that the *displacement* is in the direction of the *force*) can be found from

$$W = \boldsymbol{F}\Delta d. \tag{1}$$

If the *force* $\boldsymbol{F}$ is not constant, but we know its average magnitude $\boldsymbol{F}_{\mathrm{ave}}$, this equation can be modified as:

$$W = \boldsymbol{F}_{\mathrm{ave}}\,\Delta d. \qquad \text{(again, provided that the } \textit{displacement} \text{ is in the direction of the } \textit{force} \tag{2}$$

We can also find the *work* done by a variable *force* by finding the area under the *force* versus *displacement* graph (if there is no change in the direction of motion, the magnitude of the *displacement* is equal to the *distance* traveled, so the graph of the *force* versus *position* will yield the same result)

In this experiment we will use both approaches to estimate the *work* done by *forces* on the cart as they displace the cart along the track.

PROCEDURE

PART 1 CONSTANT FORCE

1. Prepare your **Excel** data table, similar to table 1.
2. Load your **Data Studio** data from Part 1 of the last week's experiment. Pick the best run you've had.
3. For that run, create a graph of *force* versus *position*. To do that, first make the graph of the *force* versus *time* and then in the **'Data'** window, click on the icon for that run's *position* data set and drag it over the "Time (s)" label for the *x* axis in your graph. This is a bit tricky and may take a few tries.
4. In the graph of *force* versus *position* highlight your best data for that run.
5. Use **Σ tool** to find the mean value of the force for the selected data. Record it in **Excel.**
6. Use the **Smart** and **Delta tools** to find the displacement that the cart underwent during the selected period.
7. In **Excel** use equation (2) to find the *work* done on the cart by the pulling *force*.
8. Click on the small down arrow next to the **Σ tool** and from the drop down menu select **"Area".** Look at the graph and make sure that the shaded area under the graph corresponds to the data you selected. If not, re-select the data, but do so very carefully to match your original selection exactly. Record your measured value for the area under the graph of *force* versus *displacement* in **Excel**.
9. Compare the values for the work done on the cart by the pulling *force* obtained through the two methods by calculating % difference. Expect things not to be "perfect" since we are dealing with small *forces*, for which the uncertainty in their measurement are large compared with the sizes of the *forces* themselves (e.g. if the *force* has the magnitude of 2 N and the measurement uncertainty is 0.1 N then this constitutes

0.1N/2N × 100% = 5%; most of the *forces* you'll work with today will likely be smaller and consequently the uncertainty in the force measurement will be proportionally bigger. So, expect % differences in this lab to be of the order of 5% or even a bit more, unless you're really lucky)

PART 2 LINEAR FORCE

1. In this part we'll use a spring (which obeys the Hooke's Law $F = kx$) to provide us with linearly varying force to propel the cart down the track.
2. Modify last week's part 1 lab setup as shown in figure 1 below:

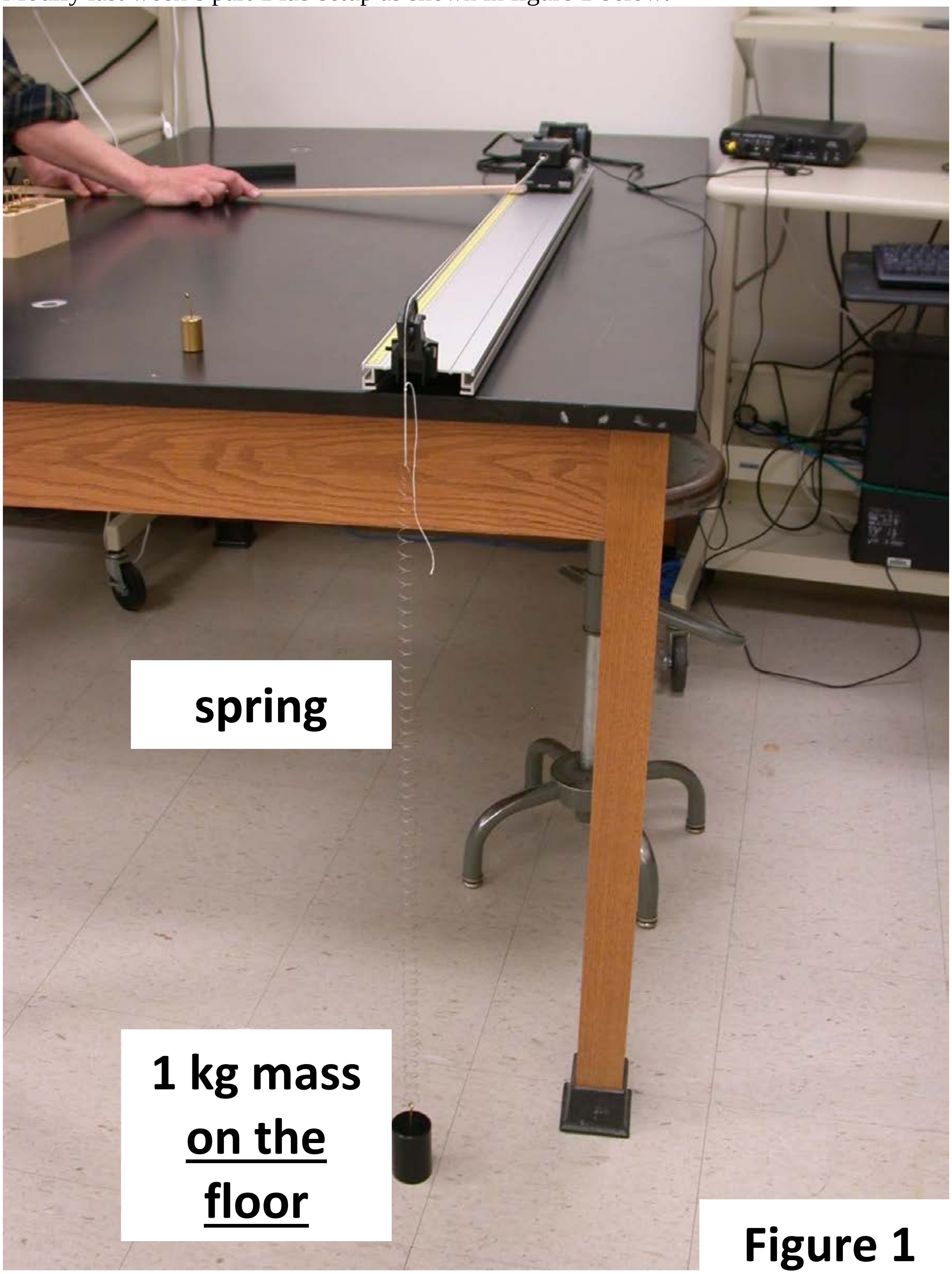

Figure 1

3. Use procedure we employed in last lab to check if the Force Sensor is correctly tared ad calibrated. Once you're confident that it works satisfactorily, tare it again while horizontal on the track and with no tension is applied to the hook.
4. Press **'START'** button of the **Data Studio** launch the cart. Make sure to catch the cart before it hits the bumper or the pulley.
5. Create a graph of *force* versus *position* for this run. Assess if you got decent enough data. If not, repeat the exercise.
6. Use the same procedure as in part 1 of this experiment to find F_{ave}, Δd and the area under the graph. Record your measurements in your **Excel** table.

PART 3 UNKNOWN FORCE

Replace the spring and 1 kg mass with a chain and set up the apparatus as shown in figure 2. Repeat the procedure from Part 2.

Figure 2

PART 4 CRAZY FORCE

1. Remove the chain and place the cart at the bottom of the track near the pulley. Use your finger to propel the cart up the track toward the **Motion Sensor**. Make sure to push the hook of the **Force Sensors** and to do so erratically, after all we want a "crazy force", and yet not to disengage your finger from the hook. Also, please make sure not to ram the cart into the **Motion Sensor**, thank you.
2. Analyze your data as you did in Parts 1, 2 and 3.
3. What did you accomplish in today's lab? Briefly summarize your findings. We aren't doing a full-fledged report this time.
4. **Additional question:** can you identify what type of force was the unknown force in Part 3? If so, explain
5. Print your Excel table (only) and attach to your summary.

Table 1.

Type of force	**Average force F_{ave} (N)**	**Displacement Δd (m)**	**$W = F_{ave}\Delta d$ (J)**	**W = area under the F vs. Δd graph (J)**	**% difference**
Constant force					
Linear force					
Unknown force					
Crazy force					

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 6

Group name: ....

Partners names: ....

....

....

INTRODUCTION:

REMINDERS:

INCLUDE UNITS.

Make sure to attach all your data and graphs. No data = No credit
Please do not hand in the whole manual, just this page and the data sheet.

SUMMARY:

Additional question: