Period of an Oscillating Object

I. Background (refer to your textbook)

Simple harmonic motion occurs when the net force acting on an object is proportional to the displacement and is in the opposite direction, $F_{net} = -kx$. In that case the position as a function of time is oscillating and given by x(t)=Xcos(ωt+ϕ_o), where

$$\omega = 2\pi f = \sqrt{\frac{k}{m}} \quad \text{and} \quad T = \frac{1}{f} = 2\pi\sqrt{\frac{m}{k}} \quad .$$

Since the force on a mass on a spring is $F = -kx$, the constant k above is just the spring constant.

II. General Experimental Information (procedures starts in the next section):

For this lab you will investigate a mass-spring system and a pendulum. You will use Data Studio interfaced with a photogate to measure the period of oscillation. The mass on the end of the spring (or bob on the pendulum) will pass through the photogate and the time for one full cycle is measured. (This is the time between every other blockage of the beam.)

A. Configuring the data aquisistion software. It will measure the period which you will then enter in an excel spread sheet.

1. Open Data Studio (remember to make sure the interface box has been turned on).

2. Click the port the photogate is plugged into. From the list of possible probes select photogate—pendulum. Drag and drop a table icon over to the period in the data window.

3. Position the photogate so that the mass will pass through the gate as it oscillates. **SPECIAL NOTE**: Have the photogate offset from the center of the mass slightly. If not, the gate may stay blocked by the weight hanger stem after the mass passes through the beam.

4. Click the Start.

5. Start the oscillation. Make sure you are getting a reading in the table. If you are not, readjust the photogate.

6. You are now ready to collect data.

III. Procedures for Period of a Mass-Spring System

A. Measure the spring constant of your spring.

From above we can write k=-F/x.
What is the meaning of F and x in this formula, how will you measure each?

You will measure k using two different methods
Method 1: Measure one value for F and one value for x. Calculate k from these values and the uncertainty Δk.

Method 2: Measure a wide range of values for F and x. Graph F vs x using Excel and fit the data using a linear regression (in the tools menu) to find the value of k and Δk.
What are the values of k and Δk? Do they agree with the results from Method 1? Which method is superior?

B. Variation of period with amplitude

With your spring and a constant mass of about 200g determine how the period depends on the amplitude of oscillation.

Analyisis: Show your results by graphing period vs amplitude. What does our theory predict for this graph? What do you find?

C. Variation of period with mass

Vary the hanging mass, M. Measure the period, T, for at least five different values of M between 50 and 250g.

Analysis:
Arrange an excel spread sheet so that it has three columns mass, experimental period, theoretical period. Fill in each as appropriate using the spreadsheet to do the calculation of the theoretical period.

It is simpler to interpret data in a graphical form than in tabular form. Graph T vs M. Do the theory agree with the experimental data?

It is simpler yet to interpret data if the graph forms a straight line. What should you graph (involving the period) against M to get a straight line?

Make the graph.

IV. Period of a Pendulum

A. Variation of period with amplitude

1. With the pendulum at a convenient length, determine whether the period depends on the amplitude of oscillation. Try several widely spaced different angles (e.g., 60°, 30°, 10°, 5°). Collect data in the same way as you did for the mass-spring system.

3. Some suggestions for analysis:

   a. Calculate the theoretical value for the period based on the mechanical properties of the system

   b. If your period does vary with amplitude, for what amplitudes (larger, smaller) does it agree most closely with the theoretical? How would you explain any variation?

B Variation with Length

1. Use at least five different values where the largest is at least 5 times the smallest (e.g. 15, 30, 45, 60 75 cm). Use the same (small) amplitude for each trial.

2. Some suggestions for analysis:

   a. Calculate the theoretical value for the period (based on the mechanical properties) and compare to the measured values.

b. Calculate the square of the measured period. Graph this versus the length. Fit a straight line to the graph and determine the slope and intercept of the line. How do the slope and intercept compare to that predicted by theory? How would you explain any discrepancies?