Name_____

Date_____ **Pd**____

UNIT 1 CP LAB 3 - Period of a Pendulum

Purpose: To determine how _____, _____, and _____ affect the period of a pendulum and construct mathematical models for the relationship between these factors and the period.

Hypothesis:

- Do some preliminary tests to see how each of the three factors in your purpose statement affect the pendulum's period. Use your observations to **predict the relationship** between each of the three variables in the purpose statement and the period and to **explain the reasoning**.

- Don't forget to refer to the "Written relationship" column on "CP Graphical Methods-Summary" when writing your hypotheses. Write a separate hypothesis for each of the three factors you will be testing.

(1)

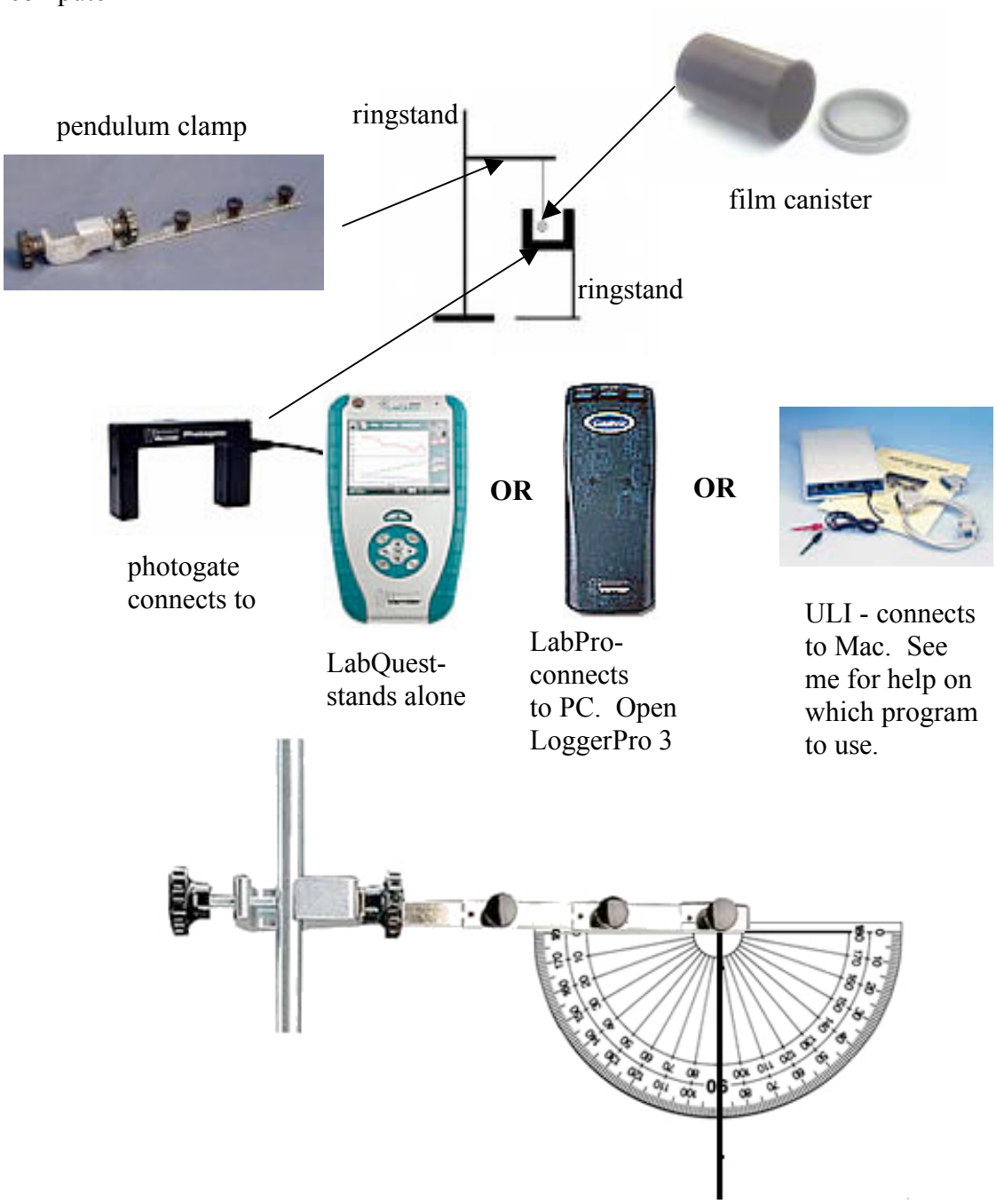
(2)

(3)

Apparatus:

film canisters filled with sand
ringstands
protractor
metric ruler
LabPro, LabQuest or ULI
computer

string
pendulum clamp
electronic balance
photogate
Logger Pro



Tape the protractor to the pendulum clamp as shown above. Make sure the string of the pendulum hangs down through the 90^{o} mark when it is at rest.

PENDULUM DATA COLLECTION

- ✓ For each factor you are testing, you will need 6 different values and 3 trials per value. You will do a separate experiment for each of the three factors.
- ✓ Record all your data in the data tables provided.
- ✓ Do not forget to record the values of your control variables.
- ✓ **NOTE:** When testing amplitude, do not pull the pendulum back further than 30^{o} from the equilibrium position. The mathematical model for large angles becomes more complicated than that of small angles.

Using LabQuest:

1. Set-up your pendulum as shown in "Apparatus".
2. Attach the Photogate to the second ring stand. Position it so that the mass blocks the Photogate while hanging straight down.
3. Connect the Photogate to DIG 1 of LabQuest and choose New from the File menu. If you have an older sensor that does not auto-ID, manually set up the sensor.
4. Set up LabQuest for data-collection with a pendulum.
   a. On the Meter screen, tap Mode.
   b. Change Photogate Mode to Pendulum Timing and select OK.
5. Temporarily hold the mass out of the center of the Photogate. If you have a Photogate with a tiny door on the inside, move it until it is shown as **Unblocked**. Observe the live readings on the screen. Block the Photogate with your hand. Note that the Photogate is shown as **Blocked** on the screen. Remove your hand and the display should change to **Unblocked**.
6. Temporarily hold the mass out of the center of the Photogate. Start data collection to prepare the Photogate.
7. Now you can perform a trial measurement of the period of your pendulum. Hold the mass from about 10^{o} from vertical and release. (For a pendulum that is 100 cm long, that corresponds to pulling the bob only about 15 cm to the side.) After five trials have been recorded, stop data collection.
8. Choose Statistics from the Analyze menu. Record the Mean Period in your data table.
9. When you are ready measure another period, simply start data collection again. You will use this method for each period measurement.

Using LabPro and Computer:

1. Set-up your pendulum as shown in "Apparatus".

2. Attach the Photogate to the second ring stand. Position it so that the mass blocks the Photogate while hanging straight down. Connect the Photogate to DIG/SONIC 1 on the interface.

3. Open LoggerPro and then the file "14 Pendulum Periods" in the *Physics with Vernier* folder. A graph of period *vs*. time is displayed.

4. If the collect button is not bright green with an arrow, LoggerPro does not recognize that your LabPro is connected to the computer. Go to **Experiment>Connect Interface>LabPro** and choose the correct port (COM1, COM2 or USB).

5. Temporarily move the mass out of the center of the Photogate. Notice the reading in the status bar of LoggerPro at the bottom of the screen, which shows when the Photogate is blocked. If you have a Photogate with a tiny door on the inside, move it until it is shown as **unblocked**. Block the Photogate with your hand; note that the Photogate is shown as **blocked**. Remove your hand, and the display should change to **unblocked**. Click ▸ Collect and move your hand through the Photogate repeatedly. After the first blocking, LoggerPro reports the time interval between every other block as the period. Verify that this is so.

6. Now you can perform a trial measurement of the period of your pendulum. Pull the mass to the side about 10º from vertical and release. Click ▸ Collect and measure the period for five complete swings. Click ■ Stop. Go to **Analyze>Statistics** or click the Statistics button, STAT, to find the Mean Period. When you are ready measure another period, simply start data collection again. You will use this method for each period measurement.

Data: *(you need to fill in the names of the variables)*

Experiment #1 _____ vs period

control variables: _____ = _____ _____ = _____

	period (s)			
	trial #1	**trial #2**	**trial #3**	**ave**

Experiment #2 _____ vs period

control variables: _____ = _____ _____ = _____

	period (s)			
	trial #1	**trial #2**	**trial #3**	**ave**

Experiment #3 _____ vs period

control variables: _____ = _____ _____ = _____

	period (s)			
	trial #1	trial #2	trial #3	ave

Data Analysis:

- ✓ Graph the data for each experiment.
- ✓ Determine a best fit curve for each graph.
- ✓ Print each graph and attach to this packet.
- ✓ Determine the mathematical model or equation for each graph.

Experiment #1 _____ vs period

Mathematical model: _____

Experiment #2 _____ vs period

Mathematical model _____

Experiment #3 _____ vs period

Mathematical model _____

Conclusions:

Experiment #1 _____ vs period

1. How are your dependent and independent related? How do you know (discuss the shape of your graph)?

2. Does this agree with your hypothesis? Why or why not?

Experiment #2 _____ vs period

3. How are your dependent and independent related? How do you know (discuss the shape of your graph)?

4. Does this agree with your hypothesis? Why or why not?

Experiment #3 _____ vs period

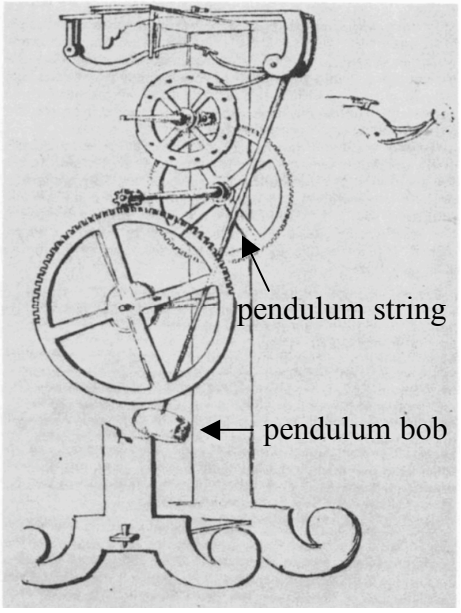
5. How are your dependent and independent related? How do you know (discuss the shape of your graph)?

6. Does this agree with your hypothesis? Why or why not?

7. All experiments have experimental error, which occurs because no measurement can be made perfectly. An example of experimental error could be when making timings with a stopwatch. Sometimes you may stop the watch too soon, sometimes too late. Sometimes the measuring tool itself may not be precise. This is also a source of error in measurements. What are areas of experimental error in this experiment?

8. How could this experiment be improved if you were to do it again?

Application:



Drawing by Galileo's (1564-1642) friend and biographer, Viviani, of an incomplete pendulum clock, which Galileo designed just before his death. It represents the first known attempt to apply a pendulum to control the rate of a clock.

9. You want to construct a pendulum clock like the one at the left. Use your graphs to determine how to make a pendulum that would make one complete swing every second.

   Describe the features of your pendulum.

   Explain how you got your answer.