Activity

4

Introduction to the Vernier Photogate

The Vernier Photogate is used to collect a wide variety of motion data. It can also be used to study the motion of toy cars, dynamics carts, objects in freefall, pendulums, projectiles, and much more.

The photogate works by projecting an infrared beam from one arm of the sensor to the other arm. When the beam is blocked the sensor sends a signal, which illuminates an LED on the top of the gate as well as triggering the software to display a blocked message in the data-collection area.

Photogates measure times at which the gate is blocked or unblocked. There are several ways of using this timing information, depending on the goal of your experiment.

- If you need to know timing information from a pulley or a picket fence object, you will need “Motion Timing.” Motion timing uses the block-to-block timing of regularly spaced marks and can be use to generate position, velocity and acceleration graphs.
- If you have an object passing through a gate, and you want to know its speed, you need “Gate” timing. Gate timing measures the block-to-unblock time interval; the ratio of the object length and the time interval is the object’s speed.
- If you have an object passing from one photogate to another you will need “Pulse Timing.” Pulse timing measures the block-to-block time for a pair of gates. For example, you might measure the average speed of a cart passing through one gate and then through a second gate. The ratio of the gate spacing and the block-to-block time is the cart’s speed. Pulse timing is not used in this book.
- If you need to measure the period of a pendulum, which is the time from the first to the third block of a photogate, you need “Pendulum Timing.”

There are also other, less common timing modes. The default timing mode is Motion Timing.

This tutorial shows you some of the ways you can use the Vernier Photogate to collect data. Refer to the part you need for the specific application in your experiment.

OBJECTIVES

In this activity, you will collect and interpret data from a Vernier Photogate in the following modes:

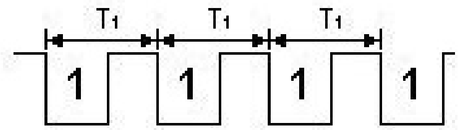
- Motion Timing mode
- Gate Timing mode
- Pendulum Timing mode

MATERIALS

Vernier data-collection interface
Logger *Pro* or LabQuest App
Cart Picket Fence
Vernier Photogate and bracket
Picket Fence

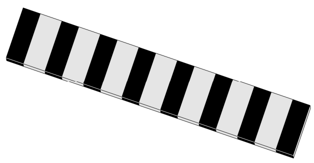
PART 1 – MOTION TIMING

When you start the data-collection software, the default mode for the photogate is Motion Timing. In this mode the software records a series of blocking events from an object that has a repeating transparent and opaque pattern.

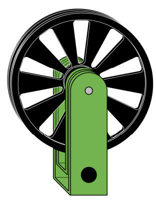


Two good examples of objects that utilize this mode are the Vernier Picket Fence (a plastic bar with a series of opaque and transparent bars) or the Vernier Ultra Pulley.

When a picket fence (see right) passes completely through a photogate, the equipment records eight blocking events, one for each black bar. The distance from the leading edge of one black bar to the next is 5 cm. Using the times from the blocking events and the 5 cm spacing, position, speed and acceleration data are determined. A smaller version of this picket fence is available for use on dynamics carts. The spacing between leading edges of the black bars on the smaller fence is 1 cm.



If you are using a pulley instead (see right), the pulley spokes block and unblock the beam. Using the blocking times and knowing the circumference of the pulley, the software can again determine position, speed and acceleration. A good example of the use of the pulley is with an Atwood's machine.

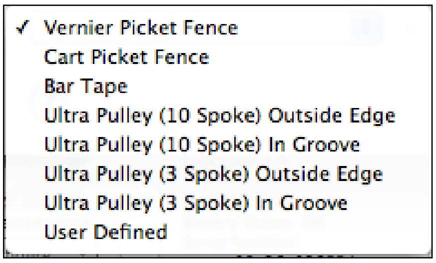


Using Logger *Pro*

1. Connect a Vernier Photogate to the interface and start Logger *Pro*.

2. Verify that the photogate and software are working by placing your hand in the photogate beam. The red LED on the top of the gate should illuminate and the software should display Blocked next to GateState above the data table in the data-collection area. If this does not happen, check all of your connections.

3. From the Experiment menu choose Set Up Sensors, specify your interface, then click on the icon of the photogate in the window. Note that Motion Timing is the default mode. When you select Set Distance or Length you can choose from a number of pre-set values or choose your own length by selecting User Defined (see right). The value and unit entered determine the steps in the distance column, which in turn scales the velocity and acceleration columns.



4. Begin collecting data, then, holding a picket fence by the edge, pass it through the photogate in a steady motion. Then stop collecting data. This can be accomplished either by clicking the Stop button or by pressing the spacebar.

5. An examination of the graph of distance *vs.* time shows that the picket fence was moving at nearly constant velocity (see Figure 1).

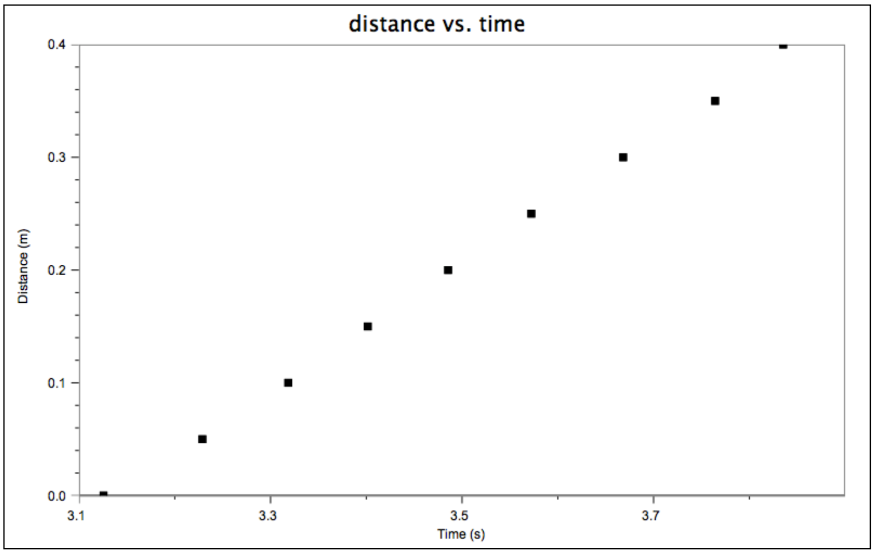


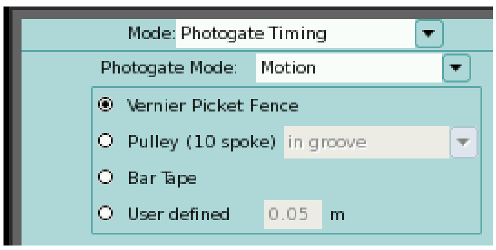
Figure 1

Using LabQuest as a standalone device

1. Connect a Vernier Photogate to LabQuest and turn on the interface or select New from the File menu.

2. Verify that the photogate and software are working by placing your hand in the photogate beam. The red LED on the top of the gate should illuminate and the software should display Blocked in the sensor window. If this does not happen, check all of your connections.

3. Tap Mode; note that Motion is the default Photogate Mode and Vernier Picket Fence is the default object to block the beam (see right). You can change the distance setting in this window. User defined allows you to set the spacing to 1 cm for a cart picket fence.



4. Begin collecting data, then, holding a picket fence by the edge, pass it through the photogate in a steady motion. The software automatically stops collecting data.

5. An examination of the graph of distance *vs.* time shows that the picket fence was moving at nearly constant velocity (see Figure 2). Unless you re-scale the graph to set 0 as the bottom of the y-axis (from the Graph Options menu), the velocity-time graph is likely to exaggerate any variation in the speed of the picket fence through the photogate.

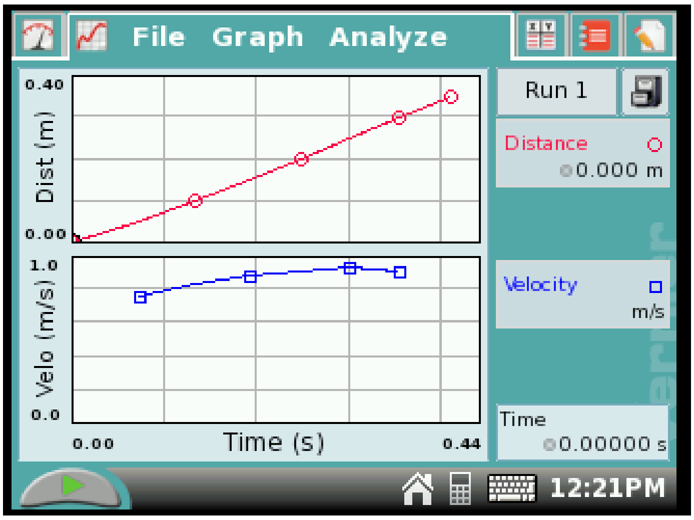
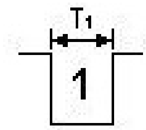


Figure 2

PART 2 – GATE TIMING

Gate timing begins when the photogate is first blocked. The timing continues until the gate is unblocked. The duration of the interruption is recorded by the software. If the length of the object is entered in the Length of Object field, the speed is calculated. The diagram at right represents the gate state during a blocking event. Initially the gate is unblocked, then blocked, and then unblocked again.



Speed calculation in Gate mode relies upon knowing the length of the object going through the gate. For some objects (the flag on the cart picket fence or note cards) this is not a problem, but other objects might be more challenging. For example, if you rolled a marble through the gate, you would need to know the diameter of the ball that went through the beam. Inaccuracies in positioning the photogate can introduce errors into the speed measurements; therefore, alignment in this type of experiment is important.

When using the Gate mode, you can also add a second photogate to measure the speed of an object through that gate. Use of two photogates in this mode would allow you to determine the change in the speed of a single object or to determine the speed of two objects.

Using Logger *Pro*

1. Connect a Vernier Photogate to the interface and start Logger *Pro*.

2. Verify that the photogate and software are working by placing your hand in the photogate beam. The red LED on the top of the gate should illuminate and the software should display

Blocked next to GateState above the data table in the data-collection area. If this does not happen, check all of your connections.

3. From the Experiment menu choose Set Up Sensors, specify your interface, then click on the icon of the photogate in the window. Select Gate Timing as the mode.

4. Click on the icon of the photogate again and select Set Distance or Length. Note that the default setting is 0.050 m. This is the width of the flag on the cart picket fence. Choose an object (your finger, a ruler, etc.) you can use to block the beam. Measure its width, then set the distance to that value.

5. Begin collecting data, pass the object slowly through the photogate, then back through the beam again, then stop the data-collection. Examine the data table. You should see something like that in Figure 3.

	Latest			
	Time (s)	State	GT (s)	Velocity (m/s)
1	1.833258	1		
2	1.854904	0	0.021646	0.924
3	3.123231	1		
4	3.165193	0	0.041962	0.477
5				

Figure 3

The time column indicates when the beam was blocked (State = 1) and then unblocked (State = 0). The GT (Gate Time) column displays the duration. The Velocity is calculated from the distance you set and the duration of the block. These data show that the object moved more slowly in the second pass through the photogate than in the first.

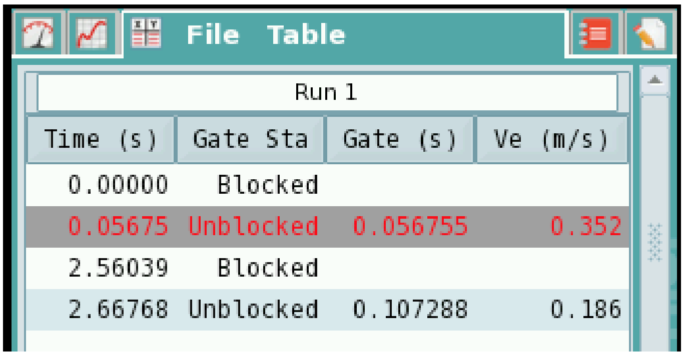
Using LabQuest as a standalone device

1. Connect a Vernier Photogate to LabQuest and turn on the interface or select New from the File menu.

2. Verify that the photogate and software are working by placing your hand in the photogate beam. The red LED on the top of the gate should illuminate and the software should display Blocked in the sensor window. If this does not happen, check all of your connections.

3. Tap Mode and select Gate as the Photogate Mode. Note that the default setting in the Length of object field is 0.050 m. This is the width of the flag on the cart picket fence. Choose an object (your finger, a ruler, etc.) you can use to block the beam. Measure its width, then set the distance to that value. Tap OK.

4. Begin collecting data, pass the object slowly through the photogate, then back through the beam again, then stop the data-collection. The software displays the Graph window, but it is easier to understand the data if you tap the Table tab to examine the data table. You should see something like that in Figure 4.



Run 1			
Time (s)	Gate Sta	Gate (s)	Ve (m/s)
0.00000	Blocked		
0.05675	Unblocked	0.056755	0.352
2.56039	Blocked		
2.66768	Unblocked	0.107288	0.186

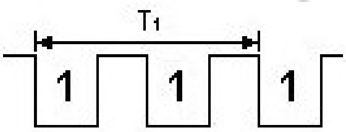
Figure 4

The time column indicates when the beam was blocked and then unblocked. The Gate column displays the duration. The Velocity is calculated from the distance you set and the duration of the block. These data show that the object moved more slowly in the second pass through the photogate than in the first.

In either application, if a second photogate is connected to the interface, data for this gate will also be displayed in the table as Gate 2.

PART 3 – PENDULUM TIMING

The Pendulum Timing mode uses a single photogate attached to an interface. The timing will begin when the photogate is first interrupted. The timing will continue until the photogate is interrupted twice more, so that you get the time for a complete swing of a pendulum or other oscillating object.



Use of this mode will give you very accurate measurements of pendula periods.

Using Logger *Pro*

1. Connect a Vernier Photogate to the interface and start Logger *Pro*.

2. Verify that the photogate and software are working by placing your hand in the photogate beam. The red LED on the top of the gate should illuminate and the software should display Blocked next to GateState above the data table in the data collection area. If this does not happen, check all of your connections.

3. From the Experiment menu choose Set Up Sensors, specify your interface, then click on the icon of the photogate in the window. Select Pendulum Timing as the mode.

4. Move your finger through the photogate, count “one thousand one”, move your finger back through the photogate, count “one thousand one” again and now pass your finger back through the gate a third time. Stop collecting data. The period of this motion is displayed in

the third column of the data table. This value should be close to 2 seconds if your timing was correct.

5. Try collecting data again, but this time move your finger through the photogate several times in a consistent back and forth motion. Stop collecting data. Judge how uniform was the period of your "pendulum motion" (see Figure 5).

	Latest		
	Time (s)	State	Period (s)
1	1.306657	1	
2	1.329886	0	
3	2.378946	1	
4	2.410011	0	
5	3.470532	1	2.163875
6	3.502938	0	
7	4.701334	1	
8	4.732922	0	
9	5.775299	1	2.304767
10	5.811170	0	
11	7.028317	1	
12	7.061474	0	
13	8.145139	1	2.369840
14	8.183325	0	

Figure 5

Using LabQuest as a standalone device

1. Connect a Vernier Photogate to LabQuest and turn on the interface or select New from the File menu.

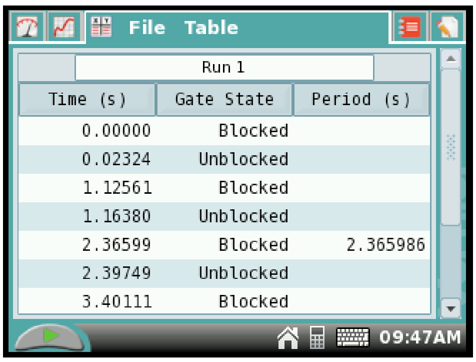
2. Verify that the photogate and software are working by placing your hand in the photogate beam. The red LED on the top of the gate should illuminate and the software should display Blocked in the sensor window. If this does not happen, check all of your connections.

3. Tap Mode and select Pendulum as the Photogate Mode. Tap OK.

4. Move your finger through the photogate, count "one thousand one", move your finger back through the photogate, count "one thousand one" again and now pass your finger back through the gate a third time. Stop collecting data.

5. This value should be close to 2 seconds if your timing was correct. Now try collecting data again, but this time move your finger through the photogate several times in a consistent back and forth motion. Stop collecting data.

6. Tap the Table tab to see the uniformity of the period of your "pendulum motion" (see Figure 6).



Time (s)	Gate State	Period (s)
0.00000	Blocked	
0.02324	Unblocked	
1.12561	Blocked	
1.16380	Unblocked	
2.36599	Blocked	2.365986
2.39749	Unblocked	
3.40111	Blocked	

Figure 6