Photo Gate Sensor DT137

The Photo Gate Sensor is a general-purpose photo gate that measures the time it takes for an object to pass between its arms.

The Photo Gate sensor is used for a wide variety of experiments in physics and physical science classes and is supplied with a mounting rod.

Typical Experiments

- Measuring the free fall acceleration
- Studying the swing of a pendulum
- Measuring the speed of a rolling object
- Measuring the speed of objects undergoing collisions

How it Works

The Photo Gate sensor has a narrow, infrared beam and fast response time, which provides very accurate signals for timing. When the infrared beam between the source and detector is blocked, the output of the photo gate is *high* (high voltage, 5 V, on the graph) and the light-emitting diode (LED) on the photo gate lights up. When the beam is not blocked; the output is *low* (low voltage, 0 V, on the graph) and the LED is off.

When working with the Fourier data logger and MultiLab software, it is recognized as a **0-5 V** sensor.

Sensor Specification

Range:	0 V – 5 V
Detector Rise Time:	180 ns
Detector Fall Time:	180 ns
Parallax Error:	For an object passing within 1 cm of the detector, with a velocity less than 10 m/s, the difference between the true and effective length is less than 1 mm
Infrared Source:	Peak at 800 nm
Data Logger Port:	Digital

Calibration

The Photo Gate sensor is shipped fully calibrated.

Measuring Timing Events with the Photo Gate Sensor and MultiLogPRO

The MultiLogPRO data logger incorporates an accurate Timer module with a resolution of 0.1 ms. The timer can measure several types of events triggered by Fourier Systems' photogates:

- Time and speed with one photo gate
- Time and speed between two gates
- Time, speed and acceleration between two gates
- Stopwatch

While in Timer mode, MultiLogPRO does not store data. To save your timing data on the computer operate the Timer module via the MultiLab software.

To use the photo gates together with other sensors operate MultiLogPRO as a data logger and then analyze the photo gate data with the aid of MultiLab’s Timing Wizard.

To perform a timing measurement:

1. Connect one or two photo gates to MultiLogPRO.

2. Use the **Forward** and **Backward** arrow buttons to navigate to the **Timing** menu.

3. Press **Enter** to display the timing menu:

```
_ _ _ _ _TIMING _ _ _ _ _

→Mode: Time Speed
 Measure: In1
 Card width: 30mm
 Gates distance: 20cm
 Start ( > )
```

   The arrow indicates that MultiLogPRO is ready to accept the timing mode.

4. Select the desired timing mode **Stopwatch, Time Speed** or **Time Speed Acc** by using the arrow buttons on the logger.

Stopwatch Mode

In this mode MultiLogPRO operates as a standard stopwatch with a resolution of 0.01 s.

```
_ _ _ _ _TIMING _ _ _ _ _

→Mode: Stopwatch
 Measure:    _ _ _
 Card width: _ _ _
 Gates distance:  _ _ _
 Start ( > )
```

1. Press **Enter** four times, and then press the **Forward** arrow to enter **Stopwatch** mode.

2. Press the **Forward** arrow to start measuring time.

3. Press the **Forward** arrow a second time to stop the watch.

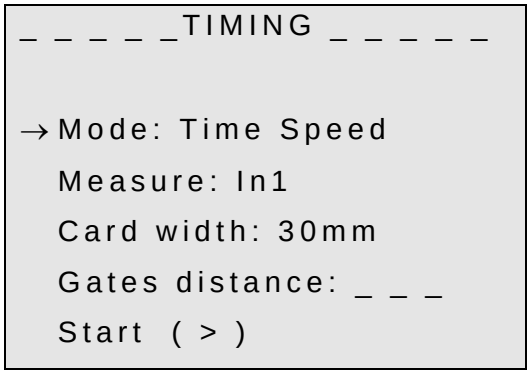
4. Press the **Backward** arrow to reset the watch.

5. Press **Escape** to exit the **Stopwatch** mode and return to the **Timing** menu.

6. Press **Escape** a second time to return to the main menu.

Time and Speed

In this mode MultiLogPRO measures time and speed at either one gate or between gates.

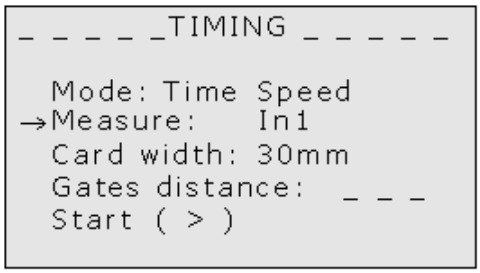


1. Press **Enter** to select this mode. The arrow then moves to the **Measure** row.

2. Use the **Forward** and **Backward** arrow buttons to select **In1** if you want to measure time and speed at one gate or **In1 → In2** if you want to measure time and speed between two gates.

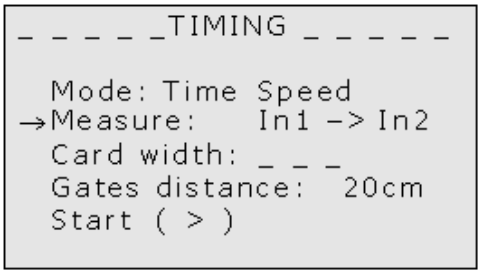
Time and speed at one gate

MultiLogPRO measures the time between blocking and unblocking the photogate at Input 1.



Time and speed between gates

MultiLogPRO measures the time between blocking the photo gate at Input 1 and blocking the photogate at Input 2.



Time and speed at one gate

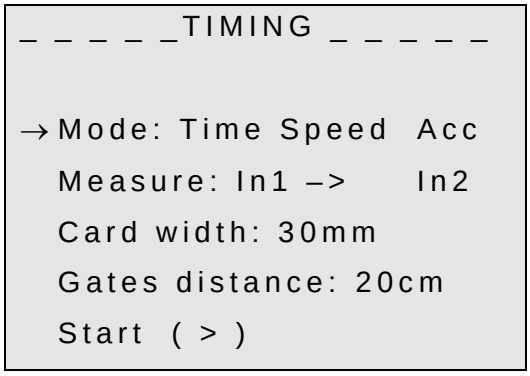
1. Press **Enter**, and then use the arrow buttons to select the card (the body that blocks the gate) width in mm between 0 to 59 mm.
2. Press **Enter** twice, then use the **Forward** arrow button to enter to timing standby mode.
3. Timing begins each time a body blocks the photo gate and ends when the photo gate is unblocked. MultiLogPRO then displays the elapsed time between entering and leaving the gate and the speed of the body.
4. Use the arrow buttons to scroll between the time and speed results.
5. Press **Escape** to return to the Timing menu.
6. Press **Escape** a second time to return to the main menu.

Time and speed between gates

1. Press **Enter** twice, then use the **Forward** arrow button to select the distance between the photo gates in cm between 0 to 99 cm.
2. Press **Enter**, and then use the **Forward** arrow button to enter to timing standby mode.
3. Timing begins each time a body enters the first photo gate (Input 1) and ends when leaving the second photo gate (Input 2). MultiLogPRO then displays the elapsed time between entering the gates and the body's average velocity.
4. Use the arrow buttons to scroll between the time and speed results.
5. Press **Escape** to return to the Timing menu.
6. Press **Escape** a second time to return to the main menu.

Time, Speed and Acceleration

In this mode MultiLogPRO measures the crossing time at the first gate, the time it takes the body to move from one gate to the second gate and the crossing time at the second gate. It returns the time between gates, the average speed and the average acceleration.



1. Press **Enter** twice, and then use the arrow buttons to select the card (the body that blocks the gate) width in mm between 0 to 59 mm.
2. Press **Enter**, and then use the **Forward** arrow button to select the distance between the photogates in cm between 0 to 99 cm.
3. Press **Enter**, and then use the **Forward** arrow button to enter timing standby mode.
   Timing begins each time a body enters the first photo gate (Input 1) and ends when leaving the second photo gate (Input 2). MultiLogPRO then displays the elapsed time between entering the gates and the body's average velocity and acceleration.
4. Use the arrow buttons to scroll between the time, speed and acceleration results.
5. Press **Escape** to return to the Timing menu.
6. Press **Escape** a second time to return to the main menu.

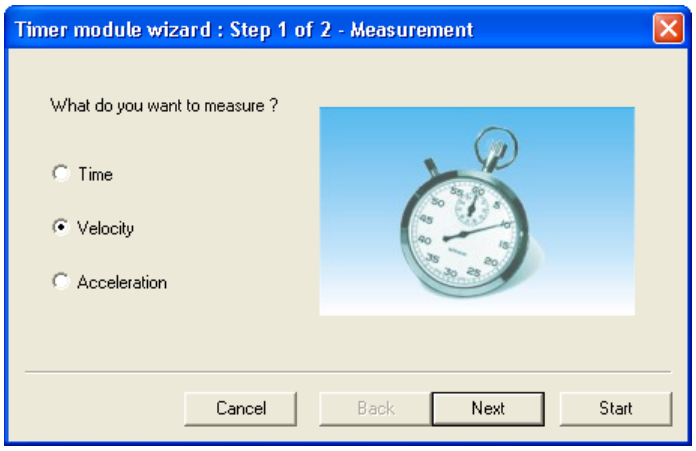
Using the Photo Gate Sensor with the MultiLogPRO or TriLink and MultiLab Software

MultiLab enables you to measure timing events with MultiLogPRO's Timer module using the **Timing Wizard** from the logger's main menu.

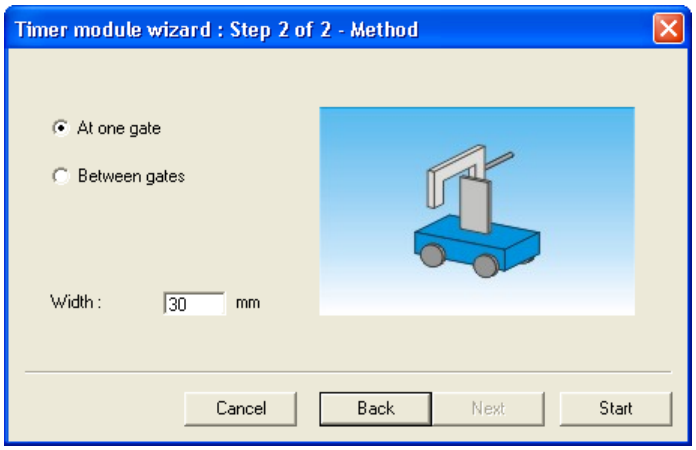
To use the photo gates together with other sensors operate MultiLogPRO as a data logger and then analyze the photo gate data with the aid of MultiLab's **Timing Wizard** from the **Analysis** menu on the main toolbar.

Working with the Timing Wizard from the Logger Menu

1. Connect MultiLogPRO to the PC.
2. Connect one photo gate to Input 1 of MultiLogPRO or two photo gates to Inputs 1 and 2 (according to the event method).
3. Click **Logger** on the main menu, and then click **Timer Module Wizard**:



4. Select the desired measurement: Time, Velocity or Acceleration.
5. Click **Next** to move to step 2 of the wizard:



6. Select the desired measuring method.
   If required enter the body's width in mm (an integer between 0 to 59), or the distance between the gates in cm (an integer between 0 to 99) in the appropriate text box (in velocity and acceleration measurements only)
7. Click **Start** to enter to timing standby mode.
   Timing begins each time a body blocks the photo gate at Input 1 and ends when unblocking the photo gate at Input 1 or Input 2 (according to the event method). MultiLab displays the results in a bar graph and in the table.

You can repeat as many measurements as you want. After each event MultiLab adds the results as a new bar in the graph and as new raw data in the table.

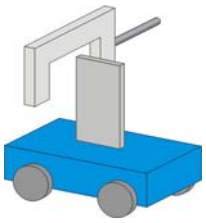
8. To exit the Timing mode click **Stop**  on the main toolbar.

Measuring Methods

The Timing Wizard offers you various methods of analyzing the different measurements. In some measurements you will be asked to enter the dimension of the moving body, or the distance between the two photo gates in order to allow for the calculation of velocity and acceleration.
The methods depend on the selected measurement:

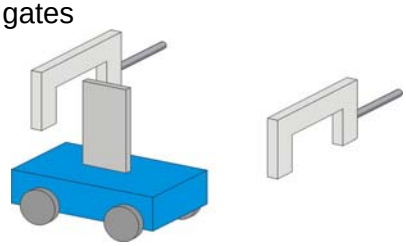
Time

- At one gate



Measures the time it takes the body to cross the photo gate (between blocking and unblocking the infrared beam)

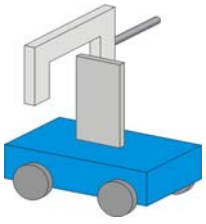
- Between gates



Measures the time it takes the body to move from one photo gate to the second photo gate (between blocking the first and blocking the second infrared beams)

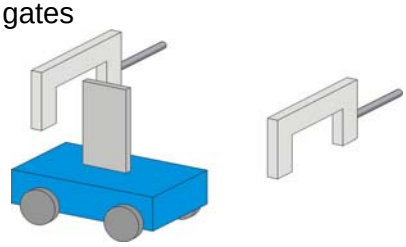
Velocity

- At one gate



Measures the time it takes the body to cross the photo gate (between blocking and unblocking the infrared beam) and returns the velocity.
You should enter the body's width in mm.

- Between gates

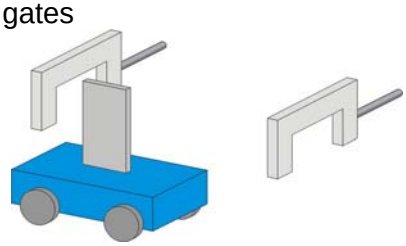


Measures the time it takes the body to move from one photo gate to the second photo gate (between blocking the first and blocking the second infrared beams) and returns the average velocity.
You should enter the distance between gates in cm.

Acceleration

- Between gates

Text box

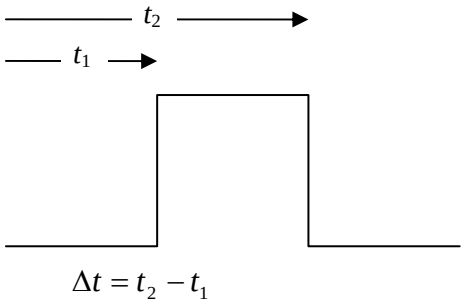


Measures the crossing time at the first gate, the time it takes the body to move from one gate to the second gate and the crossing time at the second gate and returns the average acceleration.
You should enter the body's width in mm.

Time Schemes and Calculations

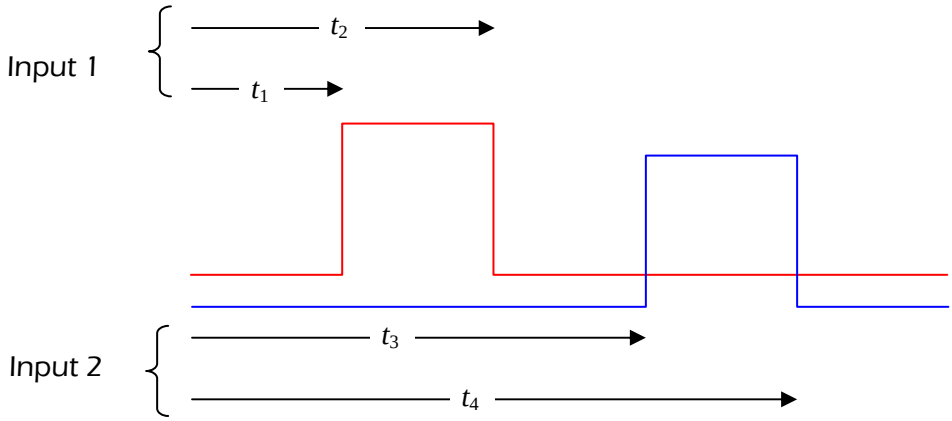
Time measurements

At one gate



Result:

Between gates

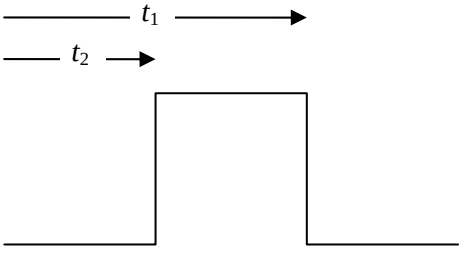


Result: $\Delta t = t_3 - t_1$

Velocity

At one gate

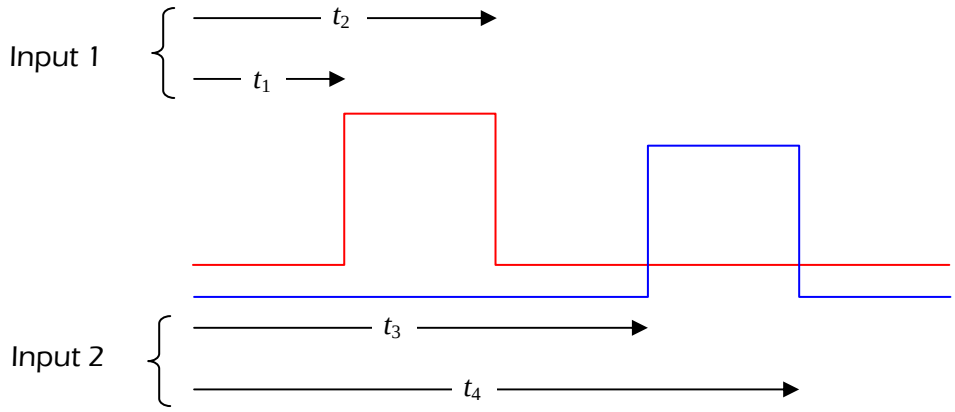
Required parameters: w – The body's width



Result: $v = \frac{w}{\Delta t}; \quad \Delta t = t_2 - t_1$

Between gates

Required parameters: L – The distance between gates

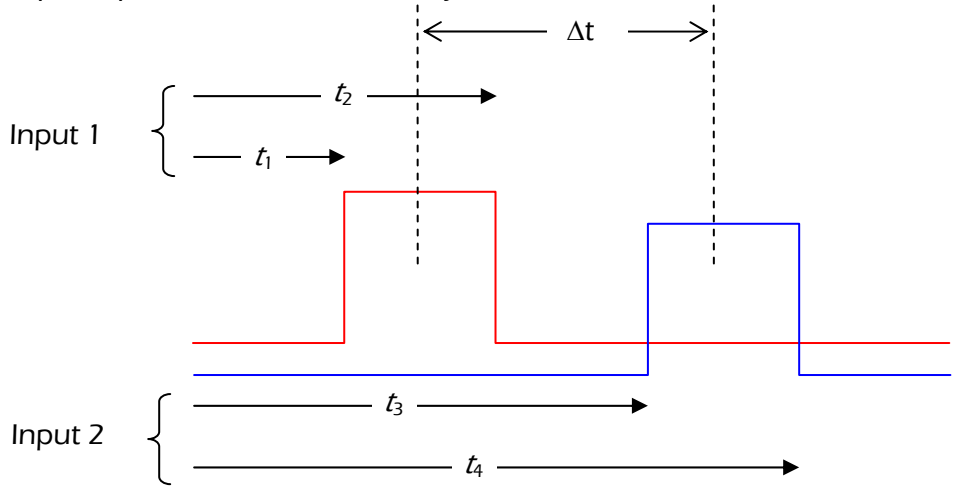


Result: $v = \frac{L}{\Delta t}; \quad \Delta t = t_3 - t_1$

Acceleration

Between gates

Required parameters: w – The body's width



$$v_1 = \frac{w}{t_2 - t_1}; \quad v_2 = \frac{w}{t_4 - t_3}$$

Result: $\Delta t = \frac{t_4 + t_3 - t_2 - t_1}{2}$

$$a = \frac{v_2 - v_1}{\Delta t}$$

Working with the Timing Wizard from the Analysis Menu

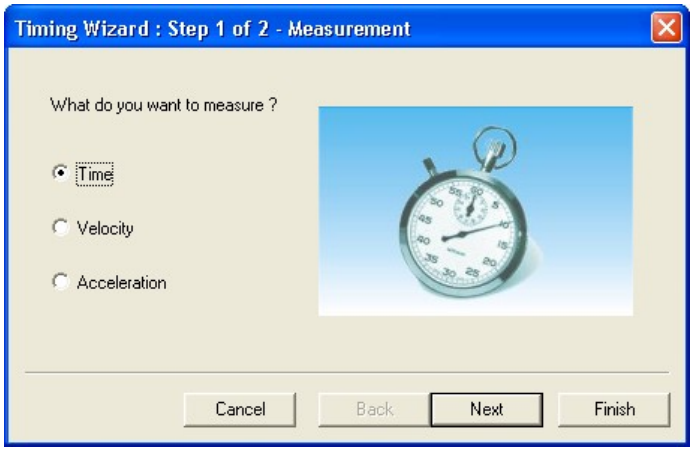
The **Timing Wizard**, accessible via the **Analysis** menu on the on the main MultiLab toolbar, enables you to easily measure and calculate many types of time events, including velocity and acceleration, with one or two photo gates.

Connect one photo gate to Input 1 or connect two photo gates to Input 1 and Input 2 in MultiLogPRO and perform the experiment. The Timing Wizard will then guide you through the analysis.

With the Timing Wizard you can measure sequences of time events at gate one and/or at gate two, or time events between the two gates. MultiLab can then calculate the velocity and acceleration. Special options make it easy to measure velocities in collisions and the time period of a pendulum or any other oscillating body.

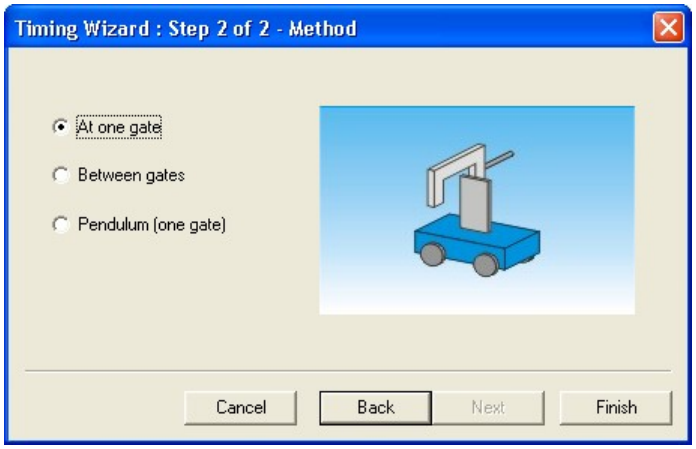
The Timing Wizard can handle multiple events. For example, when a body is crossing a photo gate several times, applying the Timing Wizard will result in a series of measurements that match the number of crossings.

1. Display the data that you wish to analyze in the graph window.
2. Click **Analysis** on the main menu, and then click **Timing Wizard** to launch step 1 of the Timing Wizard dialog:



3. Select the desired measurement: Time, Velocity or Acceleration.

4. Click **Next** to move to step 2:



5. Select the desired measuring method.

   If required enter the body's width, or the distance between the gates in cm in the appropriate text box (in velocity and acceleration measurements only).

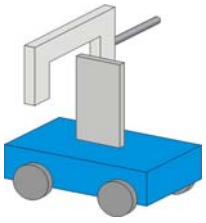
6. Click **Finish** to display the results.
7. If you want to change the method or measurement, click **Back** to return to the Timing Wizard.
8. To exit the Timing Wizard click **OK**.

Measuring Methods

The Timing Wizard offers you various methods of analyzing the different measurements. In some measurements you will be asked to enter the dimension of the moving body, or the distance between the two photo gates to allow for the calculation of velocity and acceleration.
The methods depend on the selected measurement:

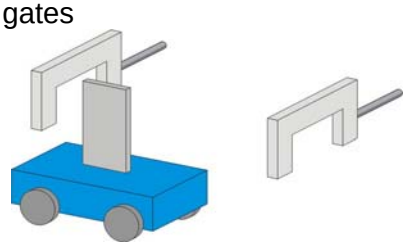
Time

- At one gate



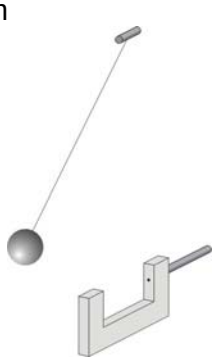
Measures the time it takes the body to cross the photo gate (between blocking and unblocking the infrared beam)

- Between gates



Measures the time it takes the body to move from one photo gate to the second photo gate (between blocking the first and blocking the second infrared beams)

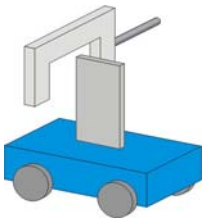
- Pendulum



Measures the time period of an oscillating body (the time interval between the first and the third blockings of the beam)

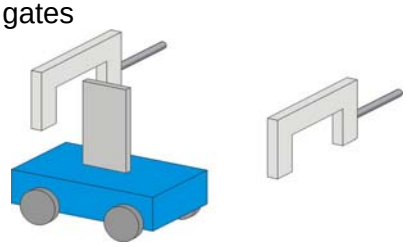
Velocity

- At one gate



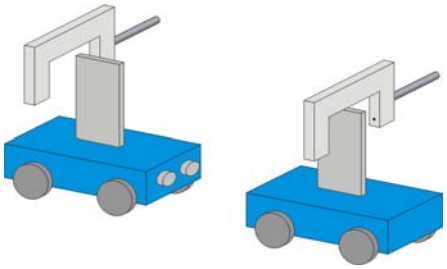
Measures the time it takes the body to cross the photo gate (between blocking and unblocking the infrared beam) and returns the velocity.
You should enter the body's width.

- Between gates



Measures the time it takes the body to move from one photo gate to the second photo gate (between blocking the first and blocking the second infrared beams) and returns the average velocity.
You should enter the distance between gates.

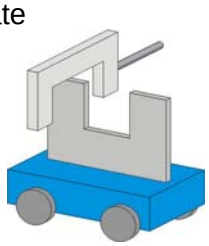
- Collisions



Measures the crossing time intervals at each gate and returns the corresponding velocities.
You should enter the bodies' width (the width of the two bodies must be identical)

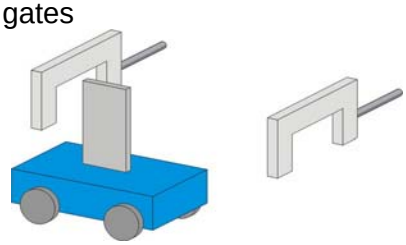
Acceleration

- At one gate



A card with two flags must be attached to the moving body (see figure to the left). The Timing Wizard measures the crossing time intervals of the two flags and returns the acceleration.
You should enter the flags width.

- Between gates

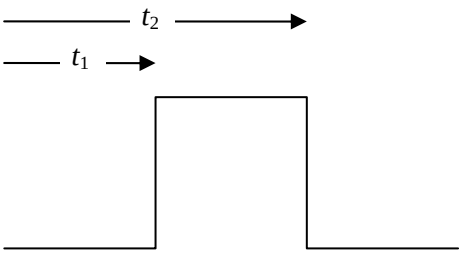


Measures the crossing time at the first gate, the time it takes the body to move from one gate to the second gate and the crossing time at the second gate and returns the average acceleration.
You should enter the body's width.

Time Schemes and Calculations

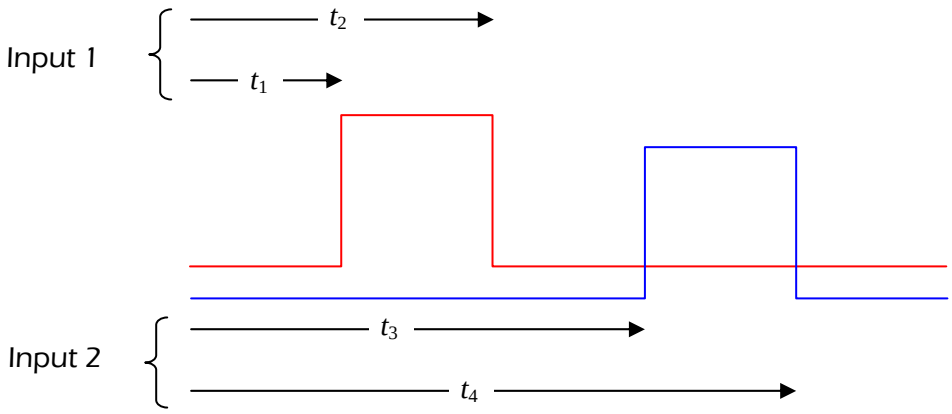
Time measurements

At one gate



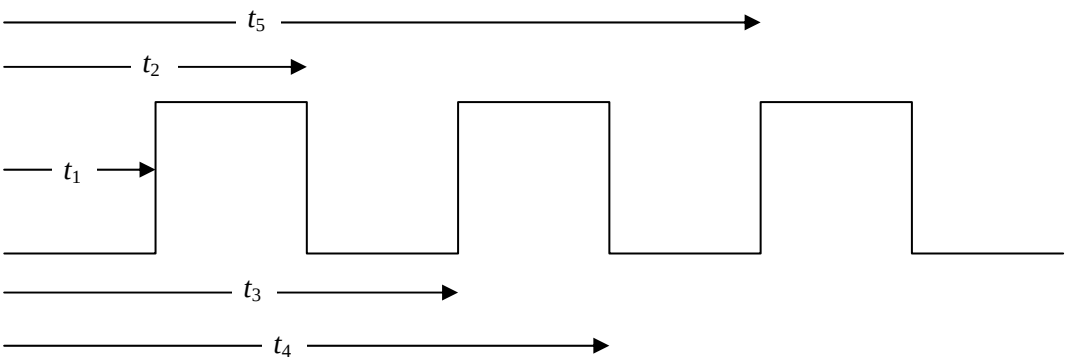
Result: $\Delta t = t_2 - t_1$

Between gates



Result: $\Delta t = t_3 - t_1$

Pendulum (one gate)

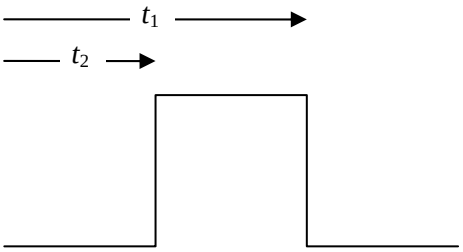


Result: $\Delta t = t_5 - t_1$

Velocity

At one gate

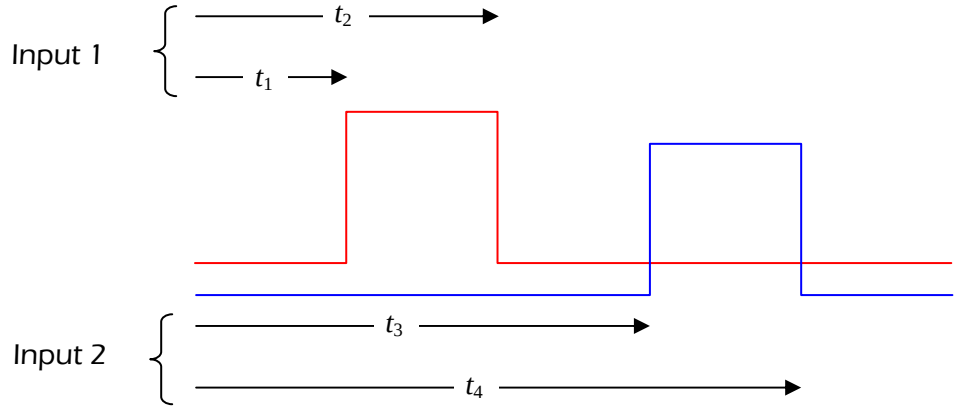
Required parameters: w – The body's width



Result: $v = \frac{w}{\Delta t}; \quad \Delta t = t_2 - t_1$

Between gates

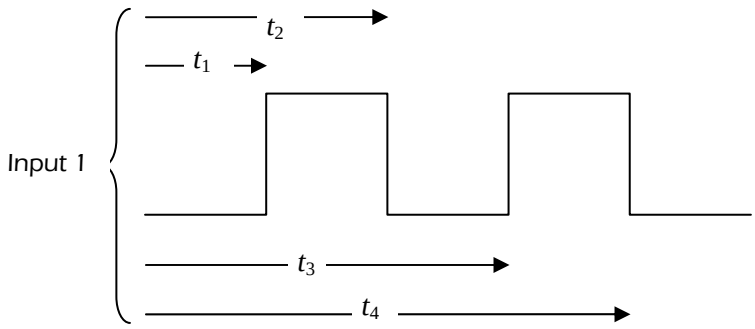
Required parameters: L – The distance between gates

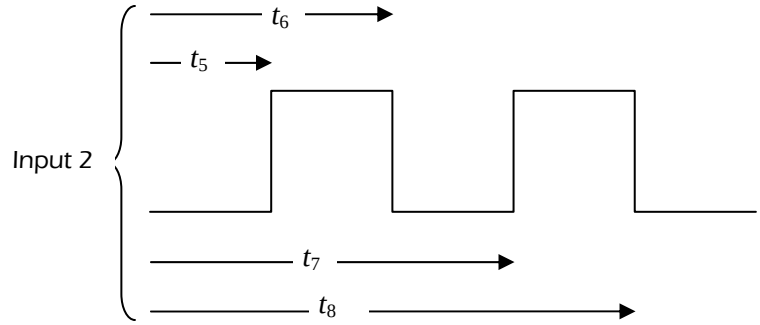


Result: $v = \frac{L}{\Delta t}; \quad \Delta t = t_3 - t_1$

Collision (two gates)

Required parameters**:** w – The bodies' width (must be identical)





Result:

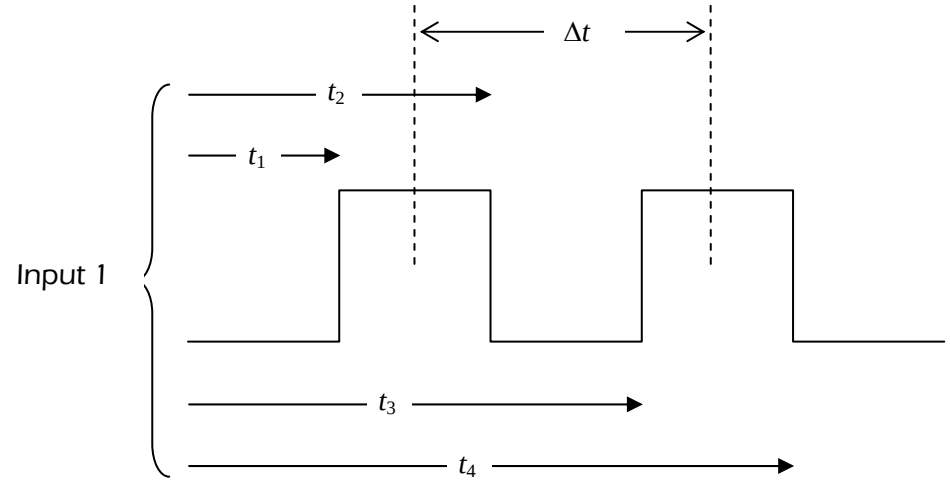
$$u_1 = \frac{w}{t_2 - t_1}; \quad v_1 = \frac{w}{t_4 - t_3}$$

$$u_2 = \frac{w}{t_6 - t_5}; \quad v_2 = \frac{w}{t_8 - t_7}$$

Acceleration

At one gate

Required parameters: w – The flags' width



$$v_1 = \frac{w}{t_2 - t_1}; \quad v_2 = \frac{w}{t_4 - t_3}$$

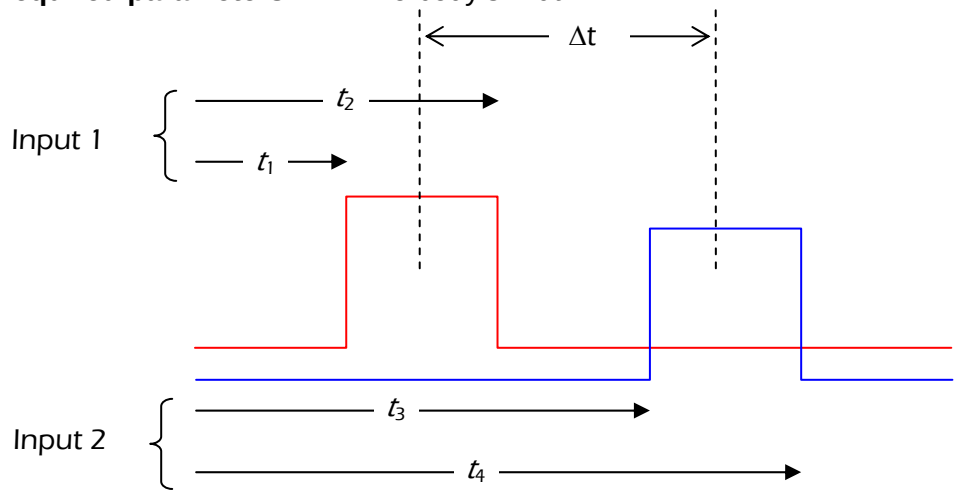
Result:

$$\Delta t = \frac{t_4 + t_3 - t_2 - t_1}{2}$$

$$a = \frac{v_2 - v_1}{\Delta t}$$

Between gates

Required parameters: w – The body's width



$$v_1 = \frac{w}{t_2 - t_1}; \quad v_2 = \frac{w}{t_4 - t_3}$$

Result:

$$\Delta t = \frac{t_4 + t_3 - t_2 - t_1}{2}$$

$$a = \frac{v_2 - v_1}{\Delta t}$$

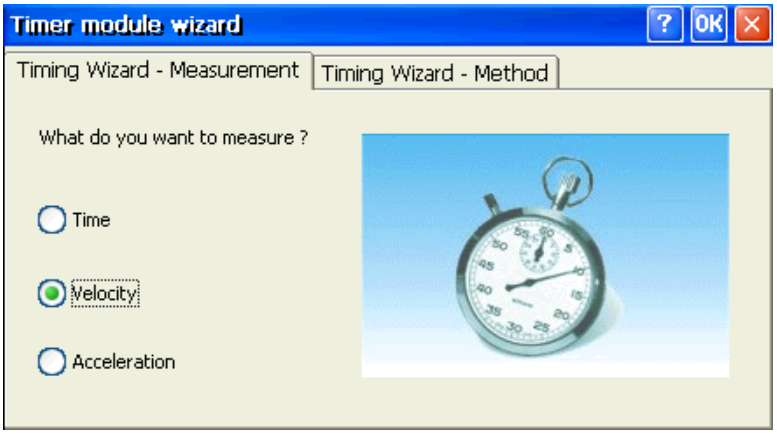
Using the Photo Gate Sensor with the Nova5000 and MultiLab Software

MultiLab software enables you to measure timing events such as Time, Velocity and Acceleration using the Photo Gate sensor and the data logger's Timing Wizard.

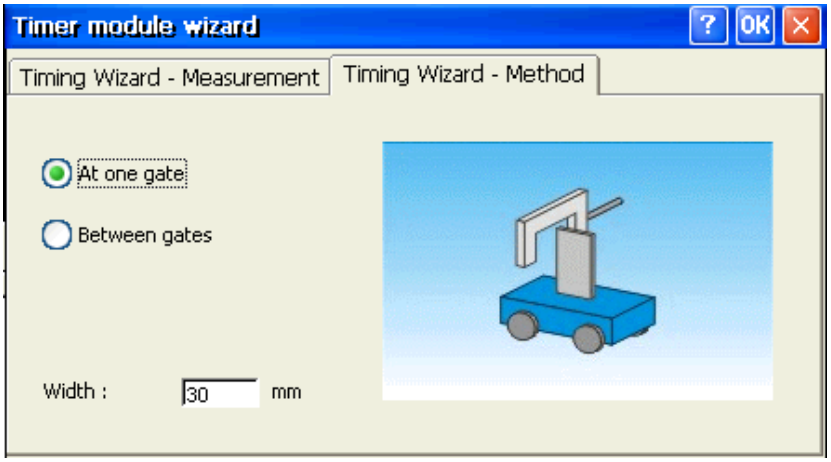
To use the photo gates together with other sensors operate the Nova5000 as a data logger and then analyze the photo gate data with the aid of MultiLab's **Timing Wizard** accessible from the **Analysis** menu.

Working with the Timing Wizard from the Logger Menu

1. Connect one photo gate to I/O-1 of the Nova5000 or two photo gates, one to I/O-1 and the other to I/O-2, depending on the type of data you require.
2. From the **Logger** menu, select **Timing Wizard** to open the Timer module.



3. Select the desired measurement: Time, Velocity or Acceleration.
4. Select the **Timing Wizard – Method** tab.



5. Select the desired measuring method.
6. If required, enter the body's width in mm (an integer between 0 and 59), or the distance between the gates in cm (an integer between 0 and 99) in the text box (for velocity and acceleration measurements only).
7. Click **OK** to exit the Timing Wizard and click **Run** to enter the timing standby mode.

   Timing begins each time a body blocks the photo gate in Input 1 and ends when unblocking the photo gate in Input 1 or Input 2 (according to the event method). MultiLab displays the results in a bar graph and in the data table.
   You can repeat as many measurements as you need. After each event, MultiLab adds the results as a new bar in the graph and as new raw data in the table.
8. To exit the timing mode select **Logger > Stop** on the main toolbar.

The measuring methods, time schemes and calculation are similar to those described above in the section: **Using the Photo Gate Sensor with the MultiLogPRO or TriLink and MultiLab Software**.

Working with the Timing Analysis from the Analysis Menu

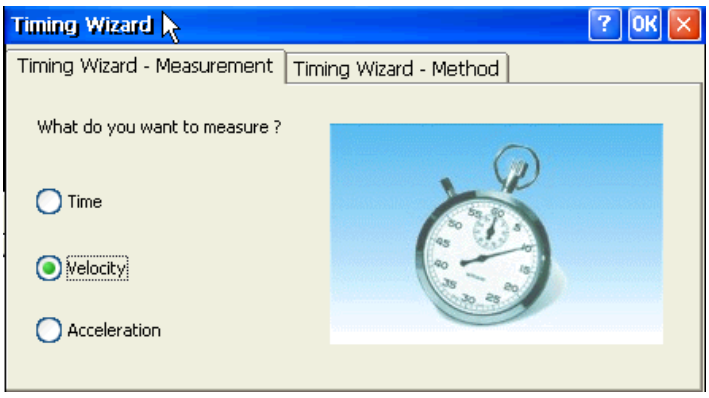
The Timing Analysis Wizard is an additional analysis tool, enabling you to easily measure and calculate many types of time events, including velocity and acceleration, with one or two photo gates.

Connect one photo gate to Input 1 of the Nova5000 or connect two photogates to Input 1 and Input 2 of the Nova5000 and perform the desired experiment. Then let the wizard guide you through the analysis of this experiment.

With the Timing Analysis Wizard you can measure sequences of time events at gate one and/or at gate two, or time events between the two gates. MultiLab can then calculate the velocity and acceleration of these events. Special options make it easy to measure velocities in collisions and the time period of a pendulum or any other oscillating body.

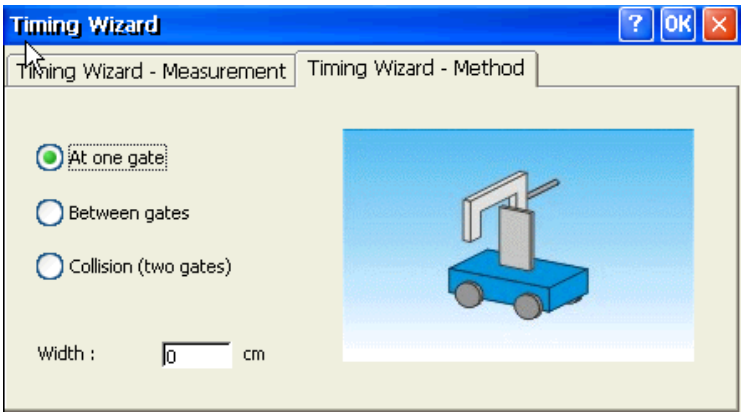
The Timing Analysis Wizard can handle multiple events. For example, if a body crosses a photo gate several times, applying the wizard will result in a series of measurements that match the number of crossings.

1. Connect one photo gate to Input 1 of the Nova5000 or connect two photo gates to Input 1 and Input 2 of the Nova5000.
2. Perform the desired experiment.
3. Display the data that you wish to analyze in the Graph window.
4. On the **Tools** menu, select **Analysis > Timing Wizard**. This launches the Timing Wizard dialog box.



5. Select the Time, Velocity or Acceleration measurement.

6. Select the **Timing Wizard – Method** tab.



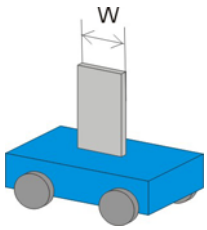
7. Select one of the measuring methods: At one gate, Between gates or Collision (two gates).
8. If required, enter the body's width, or the distance between the gates in cm in the **Width** text box.
9. Click **OK** to display the results.

The measuring methods, time schemes and calculation are similar to those described above in the section: **Using the Photo Gate Sensor with the MultiLogPRO or TriLink and MultiLab Software**.

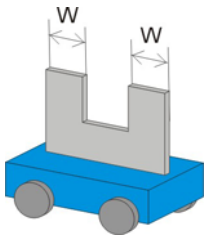
Tips on Using the Timing Wizard

- **Attach a flag to the moving body**

When measuring the motion of a moving cart it is convenient to attach a vertical **flag** to the cart (see picture below). You can mount a slotted wooden block on the cart and insert the flag onto the slot, or use masking tape to attach the flag to one side of the cart.



Use a double flag to measure acceleration at one gate. The width of the two flags must be the same.



- **Use the cursors**
  Use the cursors to select the graph and data range to which you want to apply the Timing Wizard.
- **Time resolution**
  The time resolution depends on the sampling rate. Use the table below to select a rate that meats your needs.

Rate (samples per second)	Resolution
10	0.1 s
25	0.04 s
50	0.02 s
100	0.01 s
500	2 ms
1000	1 ms
2000	0.5 ms
20800	0.05 ms

- **Use the Trigger**
  For fast events and high sampling rates use the Trigger tool to initiate the data logging.

An Example of using the Photo Gate Sensor

Impulse and Momentum

In this experiment a cart collides with a Force sensor and the change in momentum is compared to the impulse.

A photo gate is used to measure the velocities of the cart before and after the collision.

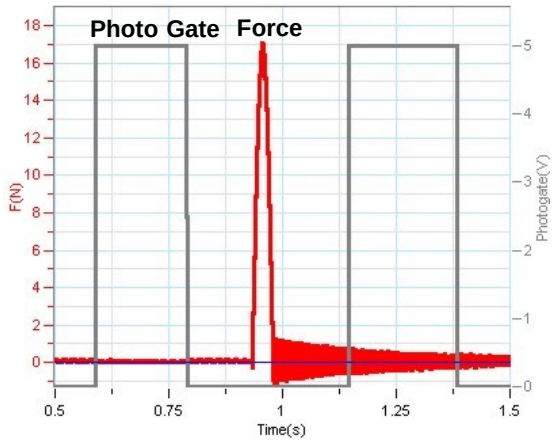


Figure 1: Using the photo gate to measure velocities in a collision

Technical Support

Please contact Fourier technical support as follows:

Web: http://www.fourier-sys.com/support_support.html
Email: support@fourier-sys.com

Consult the FAQs before contacting technical support:
http://www.fourier-sys.com/support_faq.html

Copyright and Warranty

All standard Fourier Systems sensors carry a one-year warranty, which states that for a period of twelve months after the date of delivery to you, it will be substantially free from significant defects in materials and workmanship.

This Warranty does not cover breakage of the product caused by misuse or abuse.

This Warranty does not cover Fourier Systems consumables such as electrodes, batteries, EKG stickers, cuvettes and storage solutions or buffers.