

# Measuring Instruments

## CALIPERS

The vernier caliper and the micrometer caliper, pictured here, are instruments for making precise measurements of length.

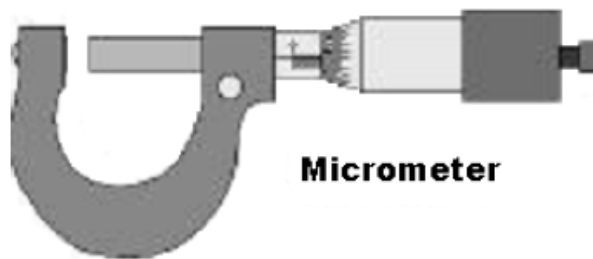
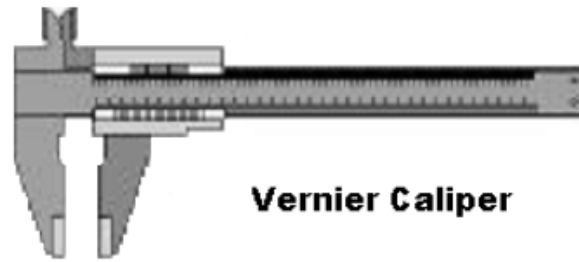


Figure 1

A vernier is an auxiliary scale that can be moved relative to a fixed scale; the vernier provides a way of accurately interpolating between scale divisions on the fixed scale.

The micrometer is a delicate, high precision instrument and should be treated with great care. **DO NOT OVERTIGHTEN THE DRUM** when making measurements. A small knob at the end of the instrument provides a means of tightening the instrument properly. To use the micrometer, place the object to be measured between the jaws and gently tighten the drum until the jaws contact the object, then twist the small knob at the end of the drum until a clicking sound is heard. The micrometer may now be read.

Your instructor will show you how to use these correctly. There is also a java applet<sup>1</sup> that shows you how to read the scale on Vernier calipers.

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<sup>1</sup><http://www.phy.ntnu.edu.tw/java/ruler/vernier.html>

## BALANCES

The balance you will use in the laboratory is a modern, digital balance. Pressing the ON/TARE button will re-zero the machine. After the 0.0 g is seen on the readout, you may place your mass on the balance. These balances are delicate instruments and should never be overloaded. 4,000 g is the operating limit.

## THE SMART TIMER

In many of the exercises in this manual, you will be called upon to measure time intervals and frequencies (number of events occurring in a given time interval). To help you with this you will use a Smart Timer. The PASCO ME-8930 Smart Timer is an accurate, versatile digital timer and measurement system for the student laboratory. The Smart Timer offers 0.1 ms timing resolution and an easy-to-use memory function. The Smart Timer measures several types of events detected with PASCO's digital sensors, including speed and acceleration using standard photogates.

### *Features*

The Smart Timer's memory function makes it easy to time events that happen in rapid succession, such as a dynamics cart passing twice through the photogate, once before and then again after a collision. The 0.1 ms resolution is especially useful in some experiments, such as measuring velocity or acceleration during free fall. The Smart Timer can calculate velocity before and after a collision between two carts using a single timer. With the new fence design and sensing logic, parallax errors are eliminated and timing accuracy is improved considerably over existing timing options. The Smart Timer's internal microcontroller also eliminates the problem of incorrect readings due to multiple passes through the same photogate by "understanding" the type of measurement selected and ignoring multiple passes. The Smart Timer has many different options for timing and calculating values based on inputs from a variety of sensors. The graphics on the keypad aid in the selection of the appropriate timing mode. Options include one or two gates, fence, and pendulum modes. These modes allow you to measure the speed of an object as it passes through the photogate or between two photogates, or to measure the period of a pendulum. The stopwatch mode lets you use the timer as an electronic stopwatch. The Smart Timer can measure speed and acceleration for both linear and rotational motion experiments. Alternatively, the time can be measured directly, and the speed and acceleration can then be calculated by the student. The speed and acceleration measurement features can be enabled or disabled using a switch inside the Smart Timer.

### *Use With Photogates*

The Smart Timer is optimized for use with PASCO's ME-9204B Accessory Photogate (available separately). These narrow-beam infrared photogates plug directly into the Smart Timer and are used to provide the timing signals. An LED in one arm of the photogate emits a narrow infrared beam. As long as the beam strikes the detector in the opposite arm of the photogate, the signal to the timer indicates that the beam is unblocked. When an object blocks the beam so it doesn't strike the detector, the signal to the timer changes. In one gate mode, a single photogate lets you measure the time, velocity, or acceleration of a fence as it passes through the photogate. Two photogates are used for collision experiments using one or two carts or for experiments where the velocity of a cart must be measured at two different points. In two gate mode, two photogates are used and the time to travel between the two can be measured. This mode can also be used to

measure time of flight using the ME-6810 Time-of-Flight Accessory.

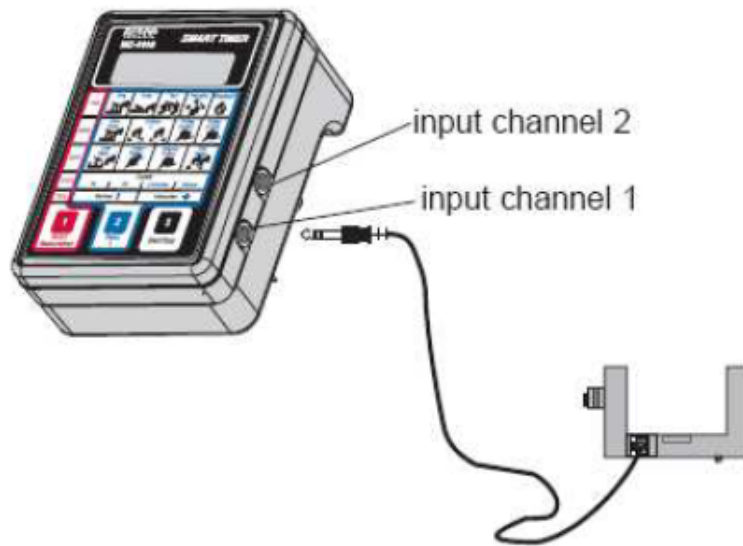


Figure 2

## Quick Cross-Reference for Suggested Activities and Smart Timer Modes


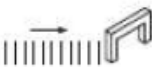
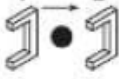










<b>TIME</b>	<b>One Gate</b> 	<b>Fence</b> 	<b>Two Gates</b> 	<b>Pendulum</b> 	<b>Stopwatch</b> 
	<ul style="list-style-type: none"> <li>• Use the time measurement to calculate the speed of a cart.</li> </ul>	<ul style="list-style-type: none"> <li>• Use time measurements to determine the acceleration of a cart or the acceleration due to gravity of a Picket Fence.</li> </ul>	<ul style="list-style-type: none"> <li>• Use the time measurement to calculate the launch speed of a ball.</li> <li>• Operate the Time-of-Flight Accessory</li> </ul>	<ul style="list-style-type: none"> <li>• Measure the period of a pendulum.</li> </ul>	<ul style="list-style-type: none"> <li>• Time students running.</li> <li>• Operate Free Fall Adapter and Laser Switch.</li> </ul>
<b>SPEED</b>	<b>One Gate (cm/s)</b> 	<b>Collision (cm/s)</b> 	<b>Pulley (rad/s)</b> 	<b>Pulley (rev/s)</b> 	
	Measure the speed of a cart.	Measure the initial and final speeds of two carts during a collision for conservation of momentum.	Measure one speed on a Smart Pulley.	<ul style="list-style-type: none"> <li>• Continuously monitor angular speed in conservation of angular momentum experiments.</li> </ul>	
<b>ACCEL</b>	<b>One Gate (cm/s<sup>2</sup>)</b> 	<b>Linear Pulley (cm/s<sup>2</sup>)</b> 	<b>Angular Pulley (rad/s<sup>2</sup>)</b> 	<b>Two Gates (cm/s)</b> 	
	<ul style="list-style-type: none"> <li>• Measure acceleration of a cart at one point on the track.</li> <li>• Measure the acceleration due to gravity (g) of a Picket Fence.</li> </ul>	Measure the acceleration of a hanging mass in rotational inertia experiments.	Measure the acceleration of a hanging mass in rotational inertia experiments.	Measure the average acceleration of a cart over the whole length of the track.	
<b>COUNTS</b>	<b>30 seconds</b>	<b>Counts for 60 seconds</b>	<b>5 minutes</b>	<b>Manual</b>	
	<ul style="list-style-type: none"> <li>• Count blocking events for the specified period of time.</li> <li>• Measure radiation emission events with the GM Tube/Power Supply.</li> </ul>				

Figure 3: Image credit: PASCO

(The above information was from the PASCO Smart Timer instruction manual.)