



*The Caliper* is a publication for users of Vernier products

# *The* Caliper

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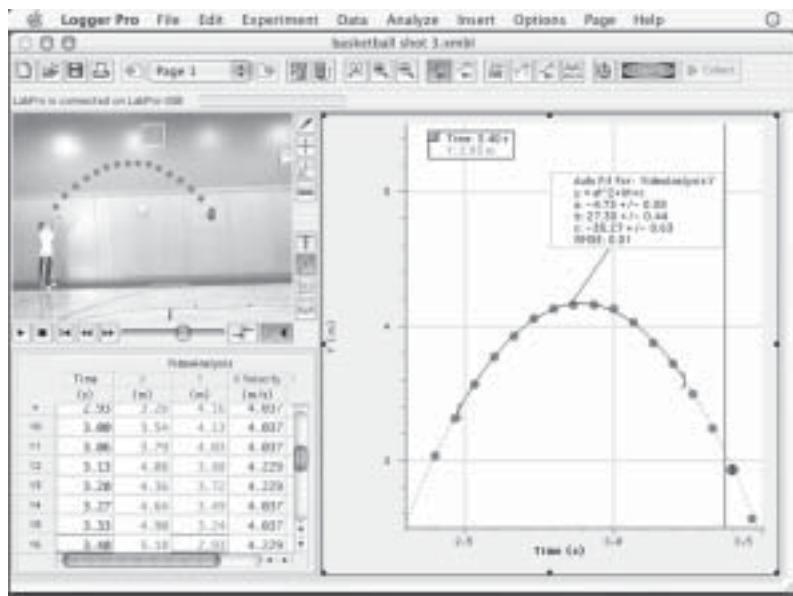
## Logger Pro® Keeps Getting Better!

While there are other applications that perform video analysis, Logger Pro 3.2 allows you to combine sensor-acquired data *with* video data.

Version 3.2 of Logger Pro is now available! This new version offers video analysis tools and strip chart mode, in addition to numerous other enhancements. If you have Logger Pro 3, you can download a free upgrade from the Vernier web site.

Many of you were excited about movies in version 3.1, in which you can insert a video clip of an experiment and synchronize it with existing sensor data. For example, you can insert a video of a chemical titration, and show the color change of an indicator while graphing the pH change. Now in version 3.2, you can extract quantitative data from the video using our new video analysis tools.

To demonstrate this feature, we took a video clip of a basketball toss



using an inexpensive web camera. The clip shows the ball in parabolic free fall motion. Using video analysis, the position of the ball as a function of time can be extracted. Frame by frame, the user clicks on the ball, and the x, y positions are recorded automatically by Logger Pro. The overall scale of the video is set by dragging across a strategically-placed meter stick visible on the floor. Velocity and other quantities can also be graphed using the calculated columns feature of Logger Pro 3.2.

Additional enhancements to Logger Pro 3.2:

- Strip charts, which are particularly useful for collecting EKG, heart rate, and weather data.
- Improved heart rate calculations, with more frequent updates.
- Improved compatibility with new versions of TI-Connect.
- Video analysis data can be synchronized with sensor data for comparison.

Logger Pro 3.2 still includes all of the features of Graphical Analysis, including import from Texas Instruments and Palm OS® handhelds.

Logger Pro 3.2 for the Vernier LabPro® interface includes the generous site-licensing of all Vernier software. One copy will outfit your entire school or college department, including students' home computers. If you have Logger Pro 3, you can download a free upgrade from [www.vernier.com/tech/lpupdates.html](http://www.vernier.com/tech/lpupdates.html). Upgrades from the original version of Logger Pro or Logger Pro 2 are just \$50 (order code ULP). Logger Pro 3.2 is for Windows® (98 and newer), Macintosh® OS 9 and OS X operating systems.

## IN THIS ISSUE

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# When Budgets are TIGHT

**Deadline for Vernier Technology Awards is Oct. 15!**

The Vernier/NSTA Technology Awards acknowledges the creative use of data-collection technology using a computer, graphing calculator, or other handheld in the science classroom. The judges are looking for an innovative idea you have implemented or plan to implement in your classroom.

#### Awards:

A total of seven \$3,000 awards will be presented:

- One award at the elementary level (grades K-5)
- Two awards at the middle school level (grades 6-8)
- Three awards at the high school level (grades 9-12)
- One award at the college level



#### Recognition:

The award-winning teachers will receive an expense-paid trip to the NSTA National Convention (expenses not to exceed \$1,000), a check for \$1,000, and \$1,000 in Vernier products. The check, Vernier gift certificate, and a commemorative plaque will be presented during the Awards Banquet at the NSTA National Convention in Atlanta in March, 2004.

The Vernier Technology Award guidelines and application form for 2004 are available to download in Adobe Acrobat format. The deadline for the receipt of applications by NSTA for the 2004 awards is October 15, 2003. See [www.vernier.com/grants/nsta](http://www.vernier.com/grants/nsta) for more information.



## Proto Board Adapters for Vernier Sensors

We recently introduced adapters which allow you to connect either our analog or digital sensors to any standard prototyping board. They were originally designed for use with the National Instruments™ NI ELVIS prototyping board. The two versions are BTA-ELV for analog sensors, and BTD-ELV for digital sensors, including Motion Detectors.



**Analog Proto Board Adapter .....** Order Code BTA-ELV ..... \$10  
**Digital Proto Board Adapter .....** Order Code BTD-ELV ..... \$10

### Did you know that Vernier . . .

- Has been recognized as one of the 100 Best Companies to Work For in Oregon for the last four years?
- Has made the list of the 50 fastest growing technology companies in Oregon six out of the last seven years?
- Supports the community by matching employee charitable contributions up to \$1,000 per year, per employee?
- Created a volunteer program for employees to spend 4 hours per month of paid time off working with the non-profit of their choice?
- Supports environmental concerns through recycling and rewarding alternative transportation to work?



# Vernier Photogate

**Lots of new functions—at the same low price**



We've updated the Vernier Photogate with three new features:

- 1) The gate is now auto-ID, so that when used with Logger Pro 3 and LabPro, the gate is automatically identified and the software is configured for photogate data collection.
- 2) You can now connect up to four photogates on a single LabPro or CBL 2 digital input using the new daisy-chain feature.
- 3) Best of all, the new Vernier Photogate includes a laser switch port. The laser switch option lets you create a very wide photogate using an ordinary laser pointer as a light source. You simply direct the laser beam into the laser port on the side of the gate. We've tested the gate with the laser 20 meters away, so you could literally drive a truck through this photogate. Use the laser gate to measure the speed of a runner, a car, or a full-size roller coaster.

**Vernier Photogate** (for LabPro & CBL 2) ..... Order Code VPG-BTD ..... \$43

**Vernier Photogate** (for ULI & original CBL) ... Order Code VPG-DG ..... \$40

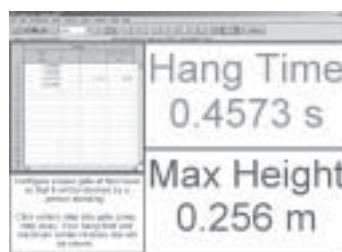
## What's Your Hang Time?

The new Vernier Photogate allows you to create human-scale timing gates. For example, it is a simple matter to create a hang-time meter. How long can a good jumper remain in the air? Let's find out.

Set a laser pointer on the floor so that the beam is just barely above floor level, aimed for a new Vernier Photogate about a meter away.

(Hint: You can use a standard office binder clip to keep the power switch depressed on a pen laser. That also keeps it from rolling away!) Next, use the new flexible timing modes in Logger Pro 3 to measure from the time the gate becomes unblocked to when it is blocked. That's an unusual timing choice, but it's perfect for this experiment. Open the file jump.xml to see the set up.

Start data collection, then step into the gate so your feet are blocking the laser beam. Jump as high as you can, landing again to block the beam.



Logger Pro 3 will report the result with photogate precision. From the jump time, we can even have Logger Pro 3 find the maximum height your center of mass rose. Have students who are basketball players and ballet dancers compare their results.

## 10 Years Ago in The Caliper

We introduced two important new hardware products, Serial Box Interface and Colorimeter, along with ULI Timer for Macintosh photogate timing.

## 15 Years Ago in The Caliper

We announced our first IBM-compatible program, Precision Timer (MS-DOS version).



## Vernier ORP Sensor

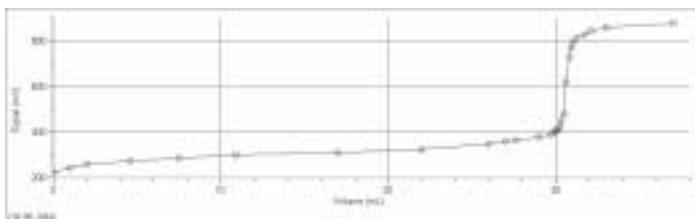
What is an ORP Sensor? "ORP" stands for "oxidation-reduction potential." Simply put, the ORP sensor measures the ability of a solution to act as an oxidizing agent or reducing agent. For example, ORP electrodes are often used to measure the oxidizing ability of chlorine in swimming pools, or to determine when the equivalence point has been reached in an oxidation-reduction reaction.



The electrode has two components: a measuring half cell comprised of platinum metal immersed in the solution in which the redox reaction is taking place, and a reference half cell (sealed gel-filled Ag/AgCl) to which the platinum half cell is referenced.

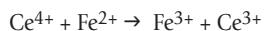
The Vernier ORP can measure redox potential in the range of -450 to +1100 mV. Readings toward the positive region of this range indicate a strong oxidizing agent, while readings toward the negative region indicate a strong reducing agent. Resolution (with LabPro) is 0.5 mV.

The ORP Sensor can be used to perform a potentiometric titration. This is a fairly common experiment in AP chemistry or college general chemistry classes. When a redox titration just exceeds its equivalence point volume, the potential measured by an ORP electrode will increase rapidly (if there is an excess of oxidizing agent) or decrease rapidly (with excess reducing agent), as seen in the graph below.

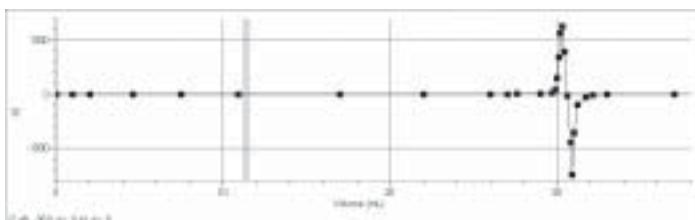


*ORP mV vs. volume data for the titration of + Fe<sup>2+</sup> solution with Ce<sup>4+</sup>*

In the reaction for the titration curve shown above



a solution containing Fe<sup>2+</sup> of unknown concentration is titrated with an oxidizing agent, ~0.1 M Ce<sup>4+</sup> standard solution (from (NH<sub>4</sub>)<sub>2</sub>Ce(NO<sub>3</sub>)<sub>6</sub>). When the equivalence point is reached, and excess Ce<sup>4+</sup> is added, a large increase in potential results. By examining these data, or performing a second derivative (also shown) or Gran plot, the equivalence point of the titration can easily be determined. With Vernier Logger Pro software, the experiment can be done one of two ways: (1) by using the ORP Sensor in Event with Entry mode (where buret volumes are manually entered), or (2) by using the Vernier Drop Counter to measure titrant volumes.



*Second derivative vs. volume plot for the titration of + Fe<sup>2+</sup> solution with Ce<sup>4+</sup>*

### ORP Sensor

For LabPro, CBL 2, and CBL ..... Order Code ORP-BTA ..... \$79  
For ULI and Serial Box Interface ..... Order Code ORP-DIN ..... \$81

## Professional Development from Texas Instruments and Vernier

### TI and Vernier Training

- Earn 35 Continuing Education Units, or three semester hour graduate credits, with an on-line course co-developed by Texas Instruments and Vernier Software & Technology. This course is intended as an introduction to data collection using TI handheld and Vernier probeware technology. Additional information regarding this option can be found at <http://education.ti.com/us/training/online/courses/vernier.html>.
- Vernier and Texas Instruments have produced a series of 1- to 5-day T<sup>3</sup> Training Institutes for which attendees may earn Continuing Education Units or professional development credits. Courses have been developed for the following subject areas: biology, chemistry, earth science and physics. For more information, see <http://education.ti.com/us/training/inperson/outlines.html#high>.

### Vernier Training

- Earn two quarter hours (1.34 semester hours) of graduate education credit through Portland State University for attending Vernier workshops that are 3 hours or longer in duration. For more information on this Professional Development option, see [www.vernier.com/pd](http://www.vernier.com/pd).
- Many states will offer Continuing Education Credit or clock hours for attendance at workshops held at professional conventions or at in-service training. We are happy to provide documentation of your attendance at any of our hands-on or demonstration workshops, hundreds of which are offered throughout the country each year.

For more details, contact us at [pd@vernier.com](mailto:pd@vernier.com).

## LabVIEW™ Updates

Are you interested in writing your own programs using the LabVIEW graphical programming language? Check out the updated LabVIEW samples posted at [www.vernier.com/labview](http://www.vernier.com/labview). You will find:

- **Simple 5.1 LabVIEW VI collection.** These are very simple VIs that are great for learning how LabPro works. They can be used with Windows, Linux, or Mac OS 9 with a serial connection to LabPro. They can also be used with a USB connection on Mac OS 9.
- **Analog Data Collect.** This is a new VI collection done with the "state machine" software design. They collect slow or fast data, support auto-ID sensors, and include some nice analysis features. These VIs can be used with serial or USB connection to a Windows or Mac OS 9 computer, or with a serial connection on a Linux computer.
- **Looking for a LabPro/LabVIEW workshop?** You're in luck. We are conducting a 3-day workshop November 6-8 in the Los Angeles area. This workshop is for high school and 2-year college physics instructors. It will be jointly lead by David Vernier and National Instruments. It is being organized by Curt Hieggelke and Tom O'Kuma as part of the TYC Physics Project. See <http://tycphysics.org> for details.

## Real Kids – Real Scientists

Dragonflytv, a PBS science show featuring real kids doing real science, used Vernier sensors in two featured investigations during their last season of broadcasts. They did one feature on the overnight temperature inside a snow shelter, and another in which they investigated whether prairie dogs make different barks when presented with different visual threats.

### Have you ever wondered, "How warm can a snow shelter keep you?"

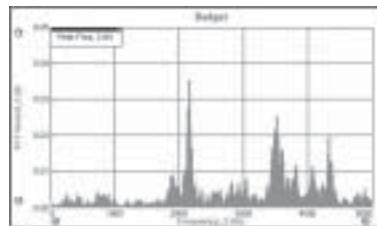


Several young scientists set out on an investigation. They built a snow shelter and camped in it overnight. They positioned one Vernier Temperature Probe inside the shelter and put the other outside. They collected data using a Vernier LabPro and a TI graphing calculator, and set the sampling rate to one sample per hour from each probe. They found that inside the shelter, the temperature remained constant at 32°F. Spikes in the data indicated where investigators lit candles for light. Once the candles were extinguished, the temperature returned to 32°F. Outside the shelter the temperature dropped below 32°F, and then began to climb after daybreak.

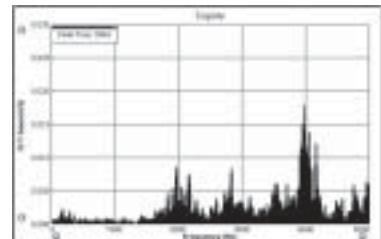
### Do Prairie Dogs Communicate through Barking Patterns?

Prairie dogs' major predators include badgers, coyotes, bobcats, and golden eagles. It is commonly thought that prairie dogs bark to warn one another of impending danger. But can a pattern be distinguished?

Prairie dogs were stimulated by different threats and recorded on a video camera with a microphone. The videos were played back and the barks recorded in *Logger Pro* software using a Vernier Microphone and a LabPro. Students found that barks from different threats contained different peak frequencies.

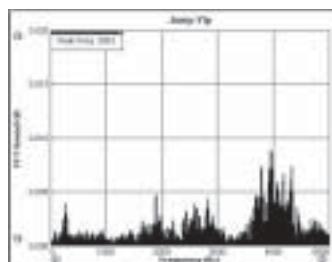


Bark from badger threat (major peaks at 2200, 3500, and 4300 Hz)



Bark from coyote threat (major peaks at 2000, 2800, and 4000 Hz)

The blacktailed prairie dog also has a display called the Jump-Yip, which involves throwing the forepaws into the air, pointing the nose straight up, and emitting an abrupt two-part vocalization. The Jump-Yip seems to mean "All's well over here. I'm going to enjoy this carrot now." During this display, the major peaks occurred between 3000-4000 Hz.



Jump-yip (major peaks clustered between 3000-4000 Hz)

Every single bark sound wave was different! An FFT of the sound reveals which primary sound frequency peaks make up the composite sound. Students concluded that human hearing can't easily distinguish prairie dog barks. However, these barks are signals that may contain important information.

Dragonflytv can be seen on your local PBS station. For more information on these and other episodes visit their web site at <http://pbskids.org/dragonflytv>.



### Vernier Celebrates Mole Day 2003!

The Vernier Mole Day Contest is on again for 2003. Here is how it works: You and your students (minimum 1 teacher and 5 students) gather on Mole Day morning, October 23. The first class to call Vernier at precisely 6:02 a.m. in your time zone wins. (Eastern, Central, Mountain, and Pacific Time Zones only. If you live outside of these time zones, use the one nearest you.) We will have our clocks set according to the National Institute of Standards and Technology. They can be found at <http://nist.time.gov/>. The winning class in each time zone will receive a prize and an award certificate. But remember, no fair calling us early. After all, would you accept  $6.01 \times 10^{23}$  for Avogadro's number? Good luck!

### Check out our DCU/stepper motor controlled webcam at [www.vernier.com/webcam](http://www.vernier.com/webcam)

The camera is located in our classroom at Vernier Software & Technology in Portland, OR. It is an example of how LabPro can be used with a LabVIEW remote panel to publish a data collection program on the internet.

## Care and Maintenance of pH Electrodes

Maintain accuracy and performance, and extend the lifetime of the electrode through proper maintenance and storage. With proper care, you may get as many as 6-8 years of use from an electrode; poor care and storage may shorten the life to 1-2 years.

### pH Electrode storage

To ensure a quick response and free-flowing liquid junction, the sensing bulb and reference junction must not be allowed to dry out. Always keep the tip in contact with a solution. The soaking bottle we include with our pH Sensors makes this very easy to do.

### Long-term storage

Fill the soaking bottle half full of pH Storage Solution. You can prepare this solution yourself: add 10 g of solid potassium chloride, KCl, per 100 mL buffer pH 4. Preferably add some buffer mold inhibitor. (Flinn Scientific sells Buffer Preservative.) Or, Vernier sells pH Storage Solution with the same recipe (500 mL bottle, order code PH-SS, \$12). Helpful tip: If you find that you or your students are occasionally spilling storage solution when the soaking bottle is not on the electrode, simply place a nickel coin into the lid, and tighten the lid for a good seal.



### Reviving dried out or slow-responding electrodes

If you have accidentally left your pH Sensor out of storage solution for a considerable period of time, you will likely be able to revive the electrode. Soak it in 0.1 M HCl solution for 2-4 hours, followed by a rinse with distilled or dionized water. Place the electrode back in soaking solution. Test its response by placing it into 2 or more buffer solutions and see if good pH readings and faster response time result. Note: Do not test response time in water with few ions (soft water, rainwater, or deionized water); pH electrodes always respond very slowly in low-ion situations!

**Can I use third-party pH Electrodes with the Vernier LabPro interface? Yes!** Our Electrode Amplifier is designed with this in mind (Electrode Amplifier, order code EA-BTA, \$40). This amplifier allows you to use a third-party pH Electrode with a BNC connector and typical Nernst equation output with our LabPro interface. The Electrode Amplifier now has auto-ID capability (for either pH or mV readings). We also have a reliable, low-cost pH Electrode that can be used with this amplifier (pH Electrode, order code 7120B, \$32).

## FAQs about Computer Data Collection

### Should I purchase a desktop or laptop computer for data collection?

Desktop computers are priced lower, but also require more counter space. Laptops have dropped significantly in price, and take up less counter space, but are a security issue for schools. We have talked to many teachers who use desktop computers, yet save counter space by placing CPU towers under counters. Flat-panel monitors have decreased significantly in price, and require less counter space than CRT monitors. Purchasing a keyboard with a trackpad eliminates the need for a mouse at each lab station.

### Do I need to worry about using chemicals and solutions near my computers?

We have never heard of any "bad-spill accidents" from chemistry teachers who use our equipment in their classes. Some teachers elevate monitors and keyboards (or laptops) on small platforms on the lab-counter surface, and CPU towers can easily be stored below a counter. Keyboards are replaceable in most cases.

### How much RAM, processing speed, and hard disk space do I need for data collection?

"Not much," is the short answer. Any of the computers listed on the right have far more capability and capacity than you will need to collect data using Vernier equipment.

### What computer operating system (OS) should I have?

Our Logger Pro 3 data-collection software runs on the latest operating systems, including Mac OS X and Windows XP. We also have software and hardware to support older operating systems.

## Computers Too Expensive? Look Again!



We often talk to teachers who tell us that they cannot afford to spend \$2000 for a computer to use for data collection. Looking at recent back-to-school computer advertisements, we notice that \$2000 can now get you as many as four or five desktop computers! Here are a few of the special deals we noticed:

- Circuit City, Inc. is selling an eMachines PC desktop with an AMD 2.3 GHz processor, 128 MB RAM, 40 GB HD, a 16-inch CRT monitor and color printer for \$370 (after \$260 in rebates).
- Dell, Inc. has a Dell Dimension with a Celeron 2.2 GHz processor, 256 MB RAM, 40 GB HD, CD-ROM drive, and a 15" flat panel monitor for \$499.
- Gateway sells a desktop computer with a Pentium 4, 2.2 GHz processor, 256 MB RAM, 30 GB HD, CD-ROM drive, and a 17" CRT Monitor for \$618.
- Apple, Inc. has a Power PC G4, with an 800 MHz G4 processor, 128 MB RAM, 40 GB HD, CD-ROM drive, and a 17" CRT monitor, for \$799.
- Amazon has a Toshiba 1805-S203 laptop with a 800 MHz processor, 128 MB RAM, 15 GB HD, and CD-ROM drive, for \$699 (after \$100 in rebates).
- Dell, Inc. has a Dell Inspiron 1100 laptop with a 2 GHz processor, 128 MB RAM, 20 GB HD, and CD-ROM drive, for \$745 (after \$50 in rebates).



## JASON Project Uses Vernier Sensors!

Texas Instruments and the JASON Foundation for Education, in cooperation with Vernier, are creating a series of hands-on activities that will engage your students in real world, inquiry-based learning. These sample lessons extend the JASON Project curriculum, bringing out the math in science and giving students opportunities to explore key concepts with TI and Vernier products. The activities will be built on JASON XV: Rainforests at the Crossroads and JASON's popular Local Aquatic Field Study. They will be available free of charge on the TI and JASON web sites starting in Fall 2003. Learn more at [www.jason.org](http://www.jason.org) or <http://education.ti.com/jason>.

Interested in trying it out? Borrow a JASON Loaner Kit through the TI Workshop Loan Program and get a free hands-on activity. Learn more about this offer at <http://education.ti.com/jason>.

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## Attention AP® and IB Science Teachers!

Provide your students with AP and IB experiments that work every time—and in a fraction of the time required in the past!

**Biology:** Data-collection technology can be used to do 7 of the 12 recommended AP Biology labs, as well as many labs that cover the IB topics:

Diffusion and Osmosis	Transpiration
Enzyme Catalysis	Physiology of the Circulatory System
Plant Pigments and Photosynthesis	Dissolved Oxygen and Aquatic Primary Productivity
Cell Respiration	

**Chemistry:** Many of the 22 AP recommended labs can be done with probeware using *Chemistry with Computers* and *Chemistry with Calculators*. Many of the labs in these books can also be used to cover the IB topics.

**Physics and Environmental Science:** Many of the experiments in our physics, Earth Science, water quality, nuclear radiation, and math lab books can be used to satisfy the laboratory portion of these courses in both AP and IB programs of study.

For a complete correlation of Vernier biology and chemistry labs with AP and IB objectives, visit [www.vernier.com/resources/ap.html](http://www.vernier.com/resources/ap.html). IB Physics and Environmental Systems correlations can also be found there.

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## Vernier Data Pro 1.3 Supports Wide Screen Graphs on the Dana by AlphaSmart®

The newest version of our handheld, data-collection software, Data Pro 1.3, supports graphs displayed in wide screen mode on the Dana. If you already have installed Data Pro, the free update is available on our web site at [www.vernier.com/downloads/dpupdates.html](http://www.vernier.com/downloads/dpupdates.html).



Data Pro now collects data from any Vernier sensor. It graphs the data, zooms in on a selected range of data, and displays a data table. It provides internal data analysis tools like curve fitting, statistics, and integral. It allows the saving and beaming of data files. It prints graphs and data tables to compatible IR-enabled printers. It automatically uploads the complete dataset as a text file to a computer during a HotSync, and the HotSync data automatically loads into a Logger Pro 3 data table.

Unlike other data collection software for handhelds, Data Pro independently performs all of the functions that you would expect of computer-based, data-collection software, but without the need for a computer.

## Vernier LabPro Goes to Denali

Pete Monte of Forest Grove, Oregon, recently climbed the highest peak in North America, Denali (also known as Mt. McKinley). Pete carried a Vernier LabPro, temperature probe, and a Gas Pressure Sensor all the way to the (20,320 ft, 6,194 m). He recorded temperatures well below freezing (in June), and pressure down to 54 kPa — approximately half of standard atmospheric pressure. Here is a photo of Pete at the top with his LabPro.



## Science Humor

Phrases and definitions for anyone reading academic papers or PhD dissertations.

**Statement:** "It has long been known."

**Translation:** "I didn't look up the original reference."

**Statement:** "Three of the samples were chosen for detailed study."

**Translation:** "The other results didn't make any sense."

**Statement:** "While it has not been possible to provide definite answers to the questions..."

**Translation:** "It was an unsuccessful experiment, but I still hope to get it published."

**Statement:** "Typical results are shown."

**Translation:** "This is the prettiest graph."

**Statement:** "It is generally believed..."

**Translation:** "A couple of others think so too."

**Statement:** "It is hoped that this study will stimulate further investigation in this field."

**Translation:** "I quit."



## TI-73 Explorer



The TI-73 Explorer (order code TI-73EX, \$66) is the newest middle grade and upper elementary graphing calculator from Texas Instruments. The TI-73 Explorer serves as a bridge between the TI-15 Explorer™ and the TI-83 Plus and TI-83 Plus Silver Edition. The TI-73 Explorer is compatible with existing TI-73 classroom products including all of our lab manuals such as *Middle School Science with Calculators*, *Physical Science with Calculators*, etc. At \$66, the TI-73 Explorer is a very affordable graphing calculator, and with the new DataMate application described below, it is an excellent choice for science and math at this grade level. A Teacher Pack of 10 TI-73 Explorer graphing calculators, 3 guidebooks, a USB Graph Link cable, a poster, 10 unit-to-unit cables, and batteries is available (order code TI-73EXTP, \$660). A TI-ViewScreen package is available (order code TI-73EXVS, \$300).



### Faster DataMate Application Available for TI Calculators

One of the biggest improvements in our DataMate calculator software during the past year has been the introduction of a fast DataMate application for TI-83 Plus and TI-83 Plus Silver Edition calculators. Users of TI-73, TI-73 Explorer, TI-89, TI-92 Plus and Voyage 200 will be excited to know that these faster-running applications are now available for their calculators.

The new applications result in DataMate running significantly faster than previously. You will really notice the difference in performance! Another advantage of using the DataMate application is that it resides in FLASH ROM, which frees up calculator memory for data.

You can obtain these newer DataMate applications as a free download at [www.vernier.com/calc/datamate.html](http://www.vernier.com/calc/datamate.html)



## Innovative Uses

Vernier equipment was used in two recent projects:

- In a flowing-water analogy to radioactive decay, the amount of water in a given vessel, measured by weight by a force sensor, corresponds to the quantity of a radioactive substance. With water flowing at a fixed rate through a capillary tube from one vessel to another, secular equilibrium can be modeled. Stephen J. Fairman, Joseph A. Johnson, and Thomas A. Walkiewicz, "Fluid Flow with Logger Pro," *Phys. Teach.* **41**, 345-350 (Sept. 2003).
- By measuring the rotational period of the tires using an attached magnet and our Magnetic Field sensor, John Buschert was able to accurately measure the power output of a car, including corrections for air drag and rolling friction. John Ross Buschert, "Measuring Horsepower and Torque Curves of a Car," *Phys. Teach.* **41**, 355-361 (Sept. 2003).

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Windows is a registered trademark of Microsoft Corporation.

Linux is a registered trademark of Linus Torvalds.

CBL, CBL 2, TI-GRAPH LINK, and TI-15 Explorer are trademarks of Texas Instruments.

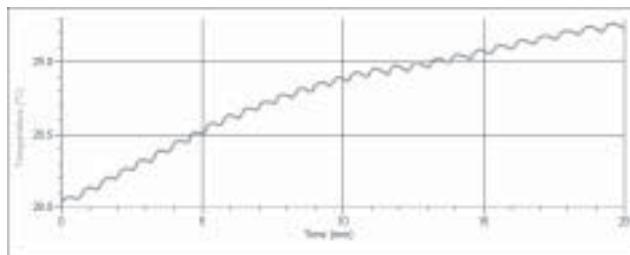
LabVIEW is a trademark of National Instruments Corporation.

Palm is a trademark and Palm OS and HotSync are registered trademarks of Palm, Inc.

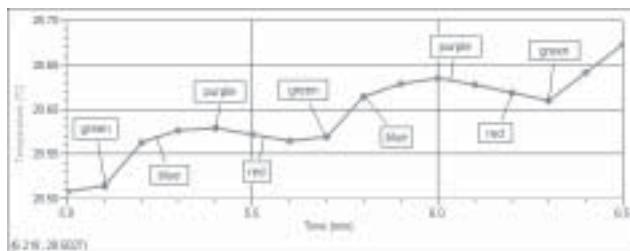
## A Four-Color Oscillating Reaction: Cerium-Catalyzed Bromate-Malonic Acid Reaction

Not only does this exciting reaction change from green to blue to purple to red, in less than a minute, but then it repeats the four color sequence continuously for over an hour! This very famous reaction is known as the Belousov-Zhabotinsky Reaction, or simply the B-Z reaction.

We thought it might be interesting to see if our sensors could be used to detect the repeating behavior of the chemical reaction. Some of the most interesting results came by using a Stainless Steel Temperature Probe. The results can be seen in these Logger Pro 3 graphs. The first graph shows 20 minutes of data collection, and about 30 cycles of the oscillating reaction. In the second graph, we have zoomed in on 2 cycles, and show where each of the colors appear.



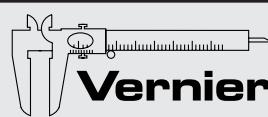
Temperature of the B-Z reaction over 20 minutes



Temperature and color changes of the B-Z reaction over two minutes

These data suggest that the mechanism exhibits a net exothermic process, followed by a somewhat smaller endothermic process, yielding a gradually increasing temperature. What would data from an ORP Sensor, Colorimeter, or pH Sensor look like for this reaction? Try it for yourself!

Flinn Scientific (800-452-1261 or [www.flinnsci.com](http://www.flinnsci.com)) sells a kit containing all the solutions and instructions needed for this reaction. Order the Fantastic Four-Color Oscillator Chemical Demonstration Kit (order code AP4833). If you wish to prepare your own solutions, instructions can be found in Bassam Shakhashiri's *Chemical Demonstrations: A Handbook for Teachers of Chemistry*, University of Wisconsin Press: Madison; 1985; Volume 2, pp 257-261. A very thorough explanation of the reaction mechanism can also be found in the Shakhashiri book.



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## Free Training!

Sign up today for one of our free, 4-hour, hands-on workshops at [www.vernier.com/workshop](http://www.vernier.com/workshop). Learn how to integrate easy and affordable data-collection technology with computers and handhelds into your science and math curriculum. This fall, we will have workshops in the following states:

■ **September**

- Texas
- **October**
- Wisconsin
- Illinois
- Iowa
- Nebraska
- South Dakota

■ **November**

- Missouri
- Indiana
- Kentucky
- Ohio
- **December**
- California

We will be conducting workshops at many of the 33 conferences we will be attending this fall. More details can be found at [www.vernier.com/workshop](http://www.vernier.com/workshop).

## You are invited...

...to a party! The 2003 NABT National Convention will be held in Portland, Oregon from October 8-11, and you are cordially invited to attend! To welcome you to our hometown, Vernier is joining with the Oregon Museum of Science and Industry (OMSI) to host a gala event in your honor. "An Evening at OMSI" will begin at 6:00, Wednesday, November 8. Dinner will be served and you will have the opportunity to

- Explore OMSI's exhibit halls.
- See a movie in the OMNIMAX theater.
- Pay a visit to the OMSI Planetarium.
- Browse in the OMSI Store and purchase items at a 10% educator discount.



Tickets for this event are \$10 each, available through NABT. To register in advance, go to [www.nabt.org/sub/pdf/convention\\_speciale.pdf](http://www.nabt.org/sub/pdf/convention_speciale.pdf)

At the convention, be sure to visit us in Booth #200 in the Exhibit Hall, and attend one of our free, hands-on, data-collection workshops on Thursday, or our software demonstration workshop on Friday morning.

We look forward to seeing you in October!

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