Vernier
Celebrating 35 Years

the
CALIPER

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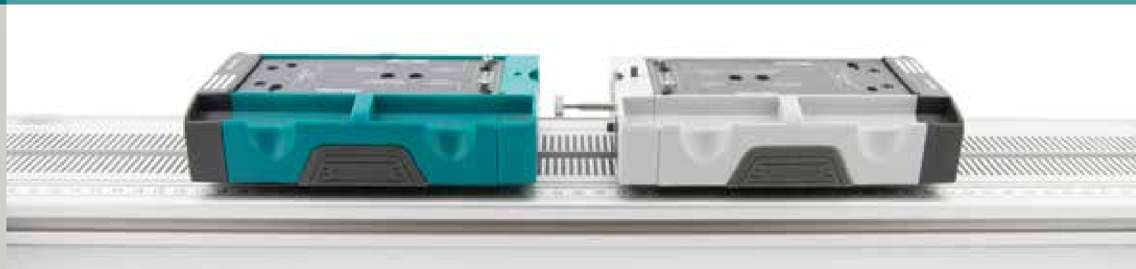
A PUBLICATION FOR USERS OF VERNIER PRODUCTS

in this issue



Superelastic Collisions with the New Vernier Dynamics Cart and Track System with Motion Encoder

Dynamics experiments are a core part of many physics courses, and low-friction carts and tracks have long been a popular tool for use with Vernier sensors. Based on customer feedback, we have redesigned our carts and accessories, making a good system even better. Renamed the Dynamics Cart and Track System, the set is available with or without our unique Motion Encoder System, and with either a 1.2 or 2.2 meter track. Additional accessories, such as a pulley and pulley bracket, are also now included—all for an even lower price.

The carts have been redesigned from the axles up. It is much easier to attach sensors and masses to the carts, and, to facilitate classroom discussions, the carts now come in two colors. A new, triggered-release mode for the spring plunger allows students to set up a superelastic collision between two carts—a collision where the kinetic energy *increases*. Such a collision still conserves momentum because the plunger spring force is internal to the two-cart system. (continued on page 2)

NEW Vernier Thermal Analysis App for the FLIR ONE™ Camera

Graphing temperature vs. time for multiple points in a thermal video.

You have probably seen thermal images showing the relative temperature of objects based on infrared emission. Vernier is developing an application to quantitatively analyze thermal images using meters and real-time graphing. Thermal Analysis, a unique and new iOS app, allows you to connect a FLIR ONE infrared camera to your iPhone®, iPod touch®, or iPad®, and graph temperature *vs.* time data. You can then export the data to the Graphical Analysis™ app for further analysis or export a thermal image movie or photo with a graph to the Photos app on your iOS device.

Using Thermal Analysis, you can analyze temperature *vs.* time data for up to four points or regions—compare temperatures in different beakers, at specific points along a heat conducting metal rod, or individual turtles basking in the sun. The app is also able to graph temperature differences between points and calculate maximum, minimum, or mean temperature of selected regions on the graph.

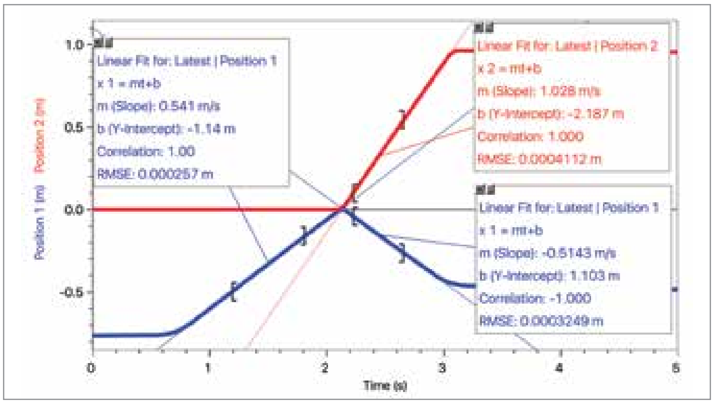
Imagine dragging a block across a carpet and seeing the temperature difference where the block was dragged. Bring alive convection in fluids. Examine animal temperatures non-invasively. These are just a few of the investigations that can be done with the Thermal Analysis app.

Download the free Thermal Analysis app from the App Store. The innovative FLIR ONE camera for iOS is available from Vernier (order code FLIRONE-IOS, $249).

Superelastic Collisions with the New Vernier Dynamics Cart and Track System with Motion Encoder

(continued from the front cover)

To demonstrate the superelastic collision feature, we started with a standard Vernier Dynamics Cart and Track System with Motion Encoder and Long Track, which includes one plunger cart and one encoder cart. We used the optional Motion Encoder Upgrade Kit (DTS-MEU, $149) to turn the plunger cart into an encoder cart. This gave us the ability to track both carts simultaneously, providing excellent position and velocity measurements.



In Logger *Pro*, we configured the Motion Encoder so that the carts shared the same coordinate system, with the same zero position and positive direction. We started the experiment with the plunger cart at rest, and rolled the plain cart into the plunger cart. On impact, the carts explosively moved apart, with the plain cart reversing direction. The position graph shows the motion clearly, with the cart represented by the blue line rolling into, and then away from, the other cart. Note the complete absence of spikes or other noise in the graph traces, made possible by the Motion Encoder System.

The cart masses were approximately the same (see table). The total kinetic energy of the two-cart system changed by more than a factor of four. The total momentum was essentially unchanged, as expected, because the spring force was internal to the system.

	Plain cart*	Plunger cart†	Total momentum	Total kinetic energy
Velocity before (m/s)	0.541	0.000	—	—
Momentum before (kg m/s)	0.173	0.000	0.173	—
Kinetic energy before (J)	0.047	0.000	—	0.047
Velocity after (m/s)	–0.514	1.028	—	—
Momentum after (kg m/s)	–0.164	0.334	0.169	—
Kinetic energy after (J)	0.042	0.171	—	0.214

*Plain cart mass: 0.3198 kg †Plunger cart mass: 0.3245 kg

In addition to studying superelastic collisions, have students use the Dynamics Cart and Track System to investigate various kinds of collisions, including elastic collisions using magnets as a nearly energy lossless bumper, lossy inelastic collisions using a spring plunger, and totally inelastic collisions using hook-and-pile tabs.

Dynamics Cart and Track System Pricing		
Dynamics Cart and Track System	DTS	$239
Dynamics Cart and Track System with Long Track	DTS-LONG	$339
Dynamics Cart and Track System with Motion Encoder	DTS-EC	$384
Dynamics Cart and Track System with Motion Encoder and Long Track	DTS-EC-LONG	$484

In the Physics Journals

A Perspective on Motion Sensors and Free Fall

Derrick E. Boucher; *American Journal of Physics*. 2015, 83, 948–951.

Those of you who use Motion Detectors frequently, especially for studying free-falling objects, may find this article enlightening. It is a detailed study of how the horizontal position of the object relative to the Motion Detector can introduce an error in measured accelerations. The errors can make the measured accelerations slightly high.

Workshop Physics and Related Curricula: A 25-Year History of Collaborative Learning Enhanced by Computer Tools for Observation and Analysis

Priscilla W. Laws; Maxine C. Willis; and David R. Sokoloff; *The Physics Teacher*. 2015, 53, 401–406.

This article describes the 25-year history of development of *Workshop Physics* and *RealTime Physics* and their influence on physics education around the world. We are proud to have worked with the authors for all of those 25 years.

The Atwood Machine Revisited Using Smartphones

Martín Monteiro; Cecilia Stari; Cecilia Cabeza; Arturo C. Marti; *The Physics Teacher*. 2015, 53, 373–374.

A smartphone is used to enhance a classic physics experiment. The phone is used as the weight on one side of an Atwood machine, and it also measures the acceleration. Our Graphical Analysis app is used to graph and analyze the data. The authors demonstrate that you can nicely show a linear relationship between the mass difference and vertical acceleration.

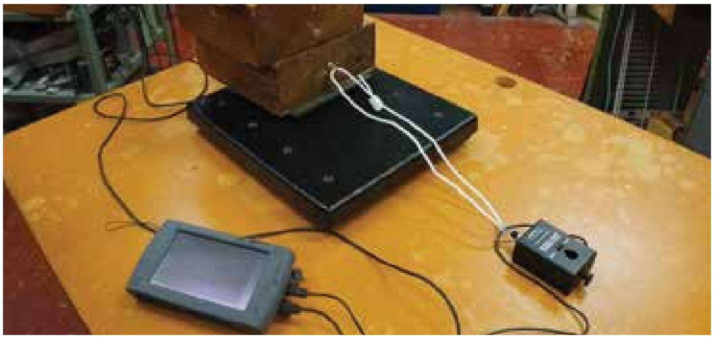
Turn Your Smartphone into a Science Laboratory

Rebecca Vieyra; Chrystian Vieyra; Philippe Jeanjacquot; Arturo Marti; and Martín Monteiro; *The Science Teacher*. 2015, 82, 32–39.

This article explains how to use the accelerometers in your smartphone to do a number of great physics experiments, including measuring the acceleration due to gravity, studying acceleration in an elevator, or measuring centripetal acceleration on a turntable. The best way to analyze the data collected this way is to use our Graphical Analysis for iOS or Android. Both apps are free downloads.

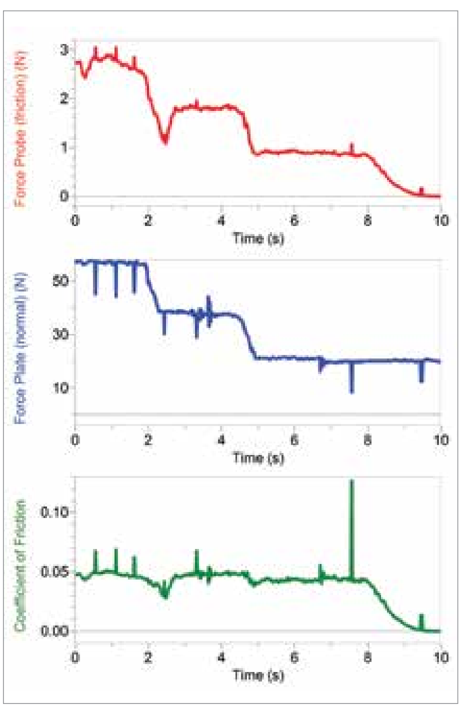
Demonstrating the Coefficient of Friction Using the Vernier Force Plate

By Bill Berner, University of Pennsylvania Department of Physics & Astronomy



Setup for coefficient of kinetic friction demonstration

The equation that characterizes kinetic friction is not hard to evaluate with measured data. But the normal force and frictional resistance are usually measured at two different times and only brought together later in the equation. While this approach yields workable numbers, it presents friction as a number rather than a process. By measuring these two forces simultaneously and in real time, the cause and effect nature of the friction process is hard to miss.



Simultaneous graphs of the normal force and friction force plus a graph of the calculated coefficient of kinetic friction

Kinetic friction can be measured by pulling an object at a constant velocity with a Dual-Range Force Sensor. With no acceleration, the zero-net-force condition means the force applied by pulling the force sensor must equal the resistance of friction. This has the added benefit of revisiting the concept of net force. If the object is pulled across a Vernier Force Plate, the normal force can be recorded simultaneously.

The objects pulled should be stackable blocks less than half the dimension of the plate, and the friction can be made more repeatable by sticking a felt furniture slider to the bottom block. The three-block strategy enables adding or removing masses while dragging. This introduces changes into the graphs of both the pulling force (friction) and the normal force. Force sensors should be zeroed with no loads to ensure valid calculations. A little practice ahead of time will let you get your speeds and times right.

Before collecting data, insert a calculated column equal to the ratio of the two forces; that is, the coefficient of kinetic friction. Doing this live clarifies the relationship between the measurements and the standard expression for kinetic friction. The graph of the calculated column is inserted below the other two force graphs. It shows all the important features of a “coefficient”: it remains constant while its parameters vary (by a factor of three in this case), and the units of its parameters cancel leaving the coefficient dimensionless.

Because space and time are limited for the block changes, it is hard to do with any finesse. It’s tough to match the motion of the added block to the moving block, and big force spikes occur. This problem is easier to avoid if blocks are removed rather than added. Starting with three blocks and removing them one at a time as the stack is dragged across the Force Plate produces cleaner data. As can be seen in the photo, the blocks are stacked with slight overhangs to make them easier to remove. The graph shows that some spikes are unavoidable, but the fundamental behavior is clear. By changing surfaces, materials, and inclines this procedure could expand to a full lab or an independent student project.

Interested in submitting a success story of your own?

We welcome your ideas and stories on how you’re using Vernier technology. Send your ideas to **innovativeuses@vernier.com**

NSTA Recommends Go Wireless® Link

Go Wireless Link received a positive review from Martin Horejsi, who writes for the National Science Teachers Association blog. His review provides a detailed account of the use of Go Wireless Link with a Flow Rate Sensor to measure the water speed of a paddle boarder.

“Go Wireless Link is a small but effective solution to expand the scope and reach of over 40 sensors. Using a Bluetooth® bridge between sensor and computer or tablet and a usable range extending up to 30 meters, the Go Wireless Link provides an upgrade to existing sensors and a new frontier in what’s possible in data collection.”

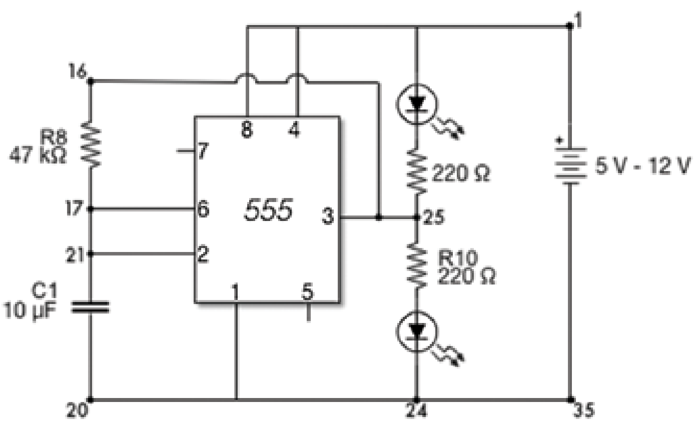
Read the full review at www.vernier.com/r161

Build a Simple Timer Circuit Using the Optional Breadboard Kit for the Vernier Circuit Board 2

VCB2-OBBK, $29

Install the Optional Breadboard Kit (VCB2-OBBK, $29) on the Vernier Circuit Board 2 (VCB2, $129) and extend your range of electronics labs. The kit includes two transistors (one PNP and one NPN), a 555 timer, a three-color LED, green and blue LEDs, a photocell, and some 220 Ω resistors. Additional wires for connecting points on the breadboard to each other and wires for connecting points on the breadboard to the VCB 2 terminals are included.

The diagram shows a simple circuit that blinks two LEDs alternately. You can easily build this circuit using the components on the Vernier Circuit Board 2 and the parts included in the Optional Breadboard Kit. The numbers next to points in the circuit correspond to terminals on the VCB2. Components with labels R8, C1, and R10 refer to components on the VCB2. Use 4 AA batteries or a LabQuest Power Supply (LQ-PS, $11) to provide power to the circuit.



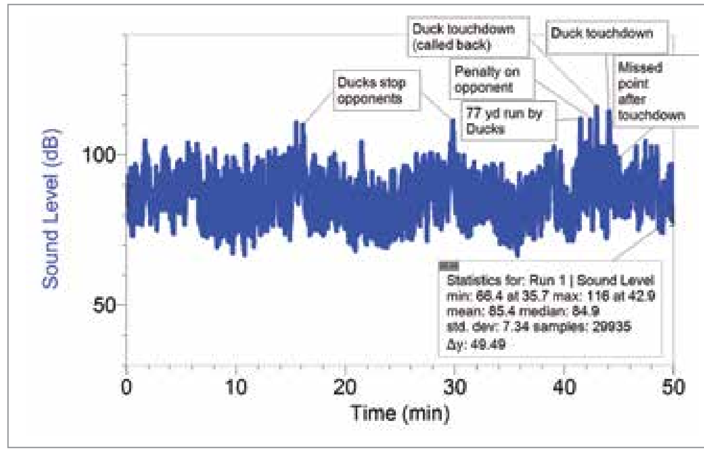
Circuit diagram for two alternately blinking LEDs

Assembled circuit

You can also use the Optional Breadboard Kit to add your own components. For example, you can provide a wider variety of capacitors or resistors for additional RC circuit options or hand a set of diodes to students to construct a bridge rectifier.

Sound Levels at Football and Soccer Games

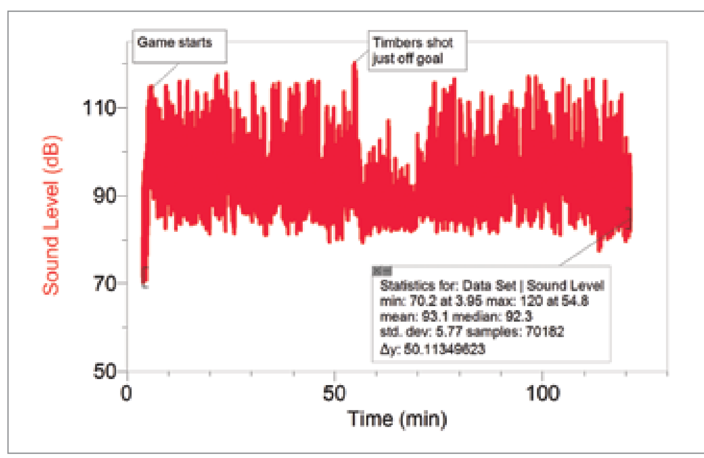
We could not resist using our new Sound Level Sensor (SLS-BTA, $69) at some local sporting events this past fall. The first graph shows the sound levels measured at about halfway up the stands in Autzen Stadium during the first half of an Oregon Ducks *vs.* Utah Utes football game.



Sound levels during the first half of the Oregon vs. *Utah game on September 26, 2015*

The graph below shows sound levels measured during a Portland Timbers Major League Soccer game at Providence Park. Data were collected in the "Timbers Army" section of the stands, which is renowned for its loud cheering and singing. Can you answer these questions based on the graph?

- When did halftime occur?
- Do you think the home team won the game?



Sound levels at the Portland Timbers soccer game on October 3, 2015

"Great lesson today using @VernierST software to show foundational concepts of collisions to start developing a 'model' for momentum!"

— @ChaconPhysics

Why does that lamp flicker so?

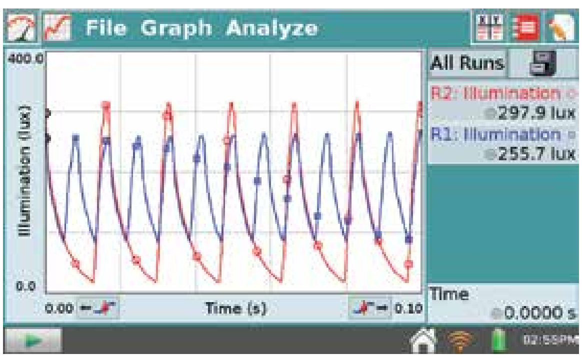
By John Gastineau, Vernier Staff Scientist and Partner

There's a table lamp in my house that flickers annoyingly. I set out to find out what it is doing.

The lamp has an LED bulb, as it is in a location I like to keep lit all evening. The inexpensive fixture has a built-in dimmer switch with two positions: full-on and low. When set to low, the light flickers noticeably. What is the nature of the intensity variation? Is there some design aspect of the lamp that makes it more noticeable?

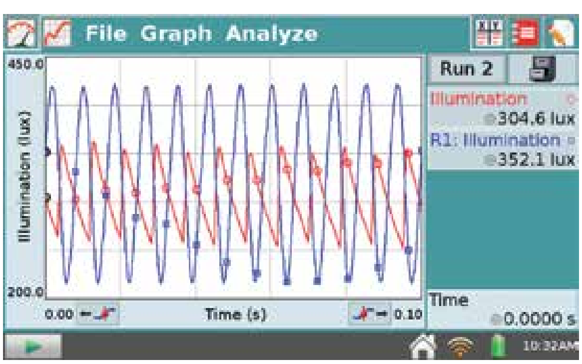
Sensor-based data collection can reveal things that happen too quickly to observe directly. I used this capability to understand the lamp behavior. To detect the intensity variation, I used a Vernier Light Sensor and configured a LabQuest for a 0.1 s duration and a 5000 points/s sampling rate. The collection rate was overkill, but I'd be sure to see details. I collected data for both lamp settings.

At full brightness, the lamp brightness changes at a 120 Hz rate. That's too fast to see easily. But at the lower setting, every other cycle is missing, so the lamp flickers at a visible 60 Hz. The lamp must pass current one way in the low setting. Note that I didn't take care to hold the Light Sensor in the same position for the two runs, so the peak intensity happened to be higher for the low position.



Light intensity vs. *time for an inexpensive dimmer and LED lamp. Red trace is dimmed; blue is full intensity. Note how the period is different by a factor of two.*

For a comparison, I did the same measurement with a more expensive LED bulb with a better dimmer. That lamp has no visible flicker at any brightness level, and indeed, the LabQuest data showed an unchanged 120 Hz variation at any brightness.

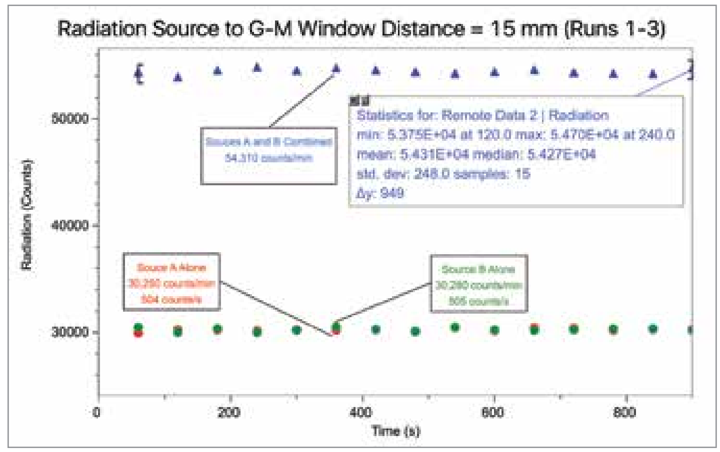


Light intensity vs. *time for a more expensive dimmer and LED lamp. Red trace is dimmed; blue is full intensity. Note the identical periods.*

Now it's clear why the inexpensive lamp flickers so much at the low setting. In this fixture, an incandescent bulb would vary in light output much less and thus not annoy, but the energy savings is important for an all-night lamp.

On the Resolving Time of the Vernier Radiation Monitor

Frequent newsletter contributor Richard Born, a professor emeritus at Northern Illinois University, developed an experiment that extends the common uses of Vernier sensors. Geiger tubes, such as those used in the Vernier Radiation Monitor (VRM-BTD, $169), all have a common behavior in that the tube is briefly insensitive to a second event that arrives quickly after another event; that is, if two events arrive within too short an interval, the second event is missed. The duration of this interval is known as the resolving time.



You can see this effect by measuring count rates with two different sources separately and then together.

In this graph, the counts per interval for the sources A and B were both around 30,000 counts/s, but together the counts were about 54,000 counts/s. Taken together, the count rate is less because the tube misses some counts, as they arrive too quickly.

Professor Born's experiment determines that for this particular tube, the resolving time is a bit less than 200 μs.

For a full description of the experiment, including a reliable vendor for the radioactive sources used and sufficient information to perform your own resolving time measurement, see www.vernier.com/r162

1981 **1991** 2016

25 Years Ago in *The Caliper*

In 1991, we celebrated our 10th anniversary as a company, and Christine commented on how much the company had grown—with 5 full-time employees! (We have added about 100 more since then.) We also introduced our second book of science projects using the Apple II, *Chaos in the Laboratory*. It included projects with A/D converters, stepper motors, a smart battery charger measuring the speed of sound, and, of course, chaos. It was STEM before there was a term for it.

Engineering

Build a Robot with a Green Thumb

What unique, creative, and interesting solutions do you think your students could devise when presented with this challenge?

> Your challenge is to design and build a sensor-controlled watering system for a potted houseplant using your EV3 robotics kit. Your device should automatically water the plant when the soil is too dry but also stop when the soil is sufficiently wet. You will use a Vernier Soil Moisture Sensor (SMS-BTA, $95) to monitor the moisture level of your plant's soil. The soil will be considered "too dry" when the moisture level falls below 20%, and sufficiently "wet" when the moisture level rises above 28%.

The programming and constructing of a sample solution for this challenge are clearly outlined in the teacher's section of our *Vernier Engineering Projects with LEGO® MINDSTORMS® Education EV3* lab book (EP-EV3, $48). In our sample solution, we attach a LEGO® pneumatic pump to a LEGO® motor. A clear plastic water bottle is equipped with a 2-hole stopper, and tubing attaches from the bottle to the pump and from the bottle to the plant. We program this robot using a MINDSTORMS® Loop block that continuously monitors the reading from the Soil Moisture Sensor. If the reading is within the range, the robot does nothing; but if it falls below the threshold value, the program activates the motor to pump air into the bottle and push water out to the plant. The program waits to allow the water to percolate and loops back to monitor the sensor reading again.

When presenting this challenge to your students, one option is to share some, or all, of the sample solution with them. Another option is to have your students fully take on the challenge by allowing them to come up with their own distinct solution. This will undoubtedly lead to some truly imaginative, interesting, and fun ways to transport, carry, or splash water on a thirsty plant. For students who finish early or who want to pursue an independent project, the book also provides project extension ideas. In one project extension, a robot monitors the amount of light that the plant receives. If the light is too low, the robot must increase the light or warn the plant owner.

A real-world challenge like this introduces your students to the engineering design process. Students learn about robotics and programming, delve deeper into scientific principles, discover how sensors work, and learn how to solve problems as a team.

For an overview of projects to test batteries, locate hidden magnets that represent "land mines," track the sun with solar panels, and more, see www.vernier.com/ep-ev3

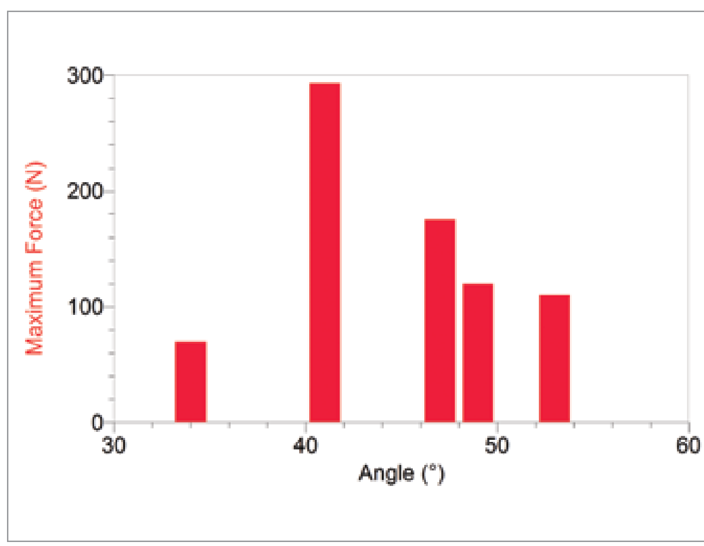
Introducing the Truss Tester Accessory

By Tom Smith, Engineering Educational Technology Specialist

The Truss Tester Accessory (VSMT-TRUSS, $128) for the Vernier Structures & Materials Tester (VSMT, $999) makes testing single trusses quick and efficient. Testing trusses can be a great engineering design project by itself, or you can use it as a building block for designing a bridge or another structure that is comprised of trusses.

VSMT-TRUSS, $128

I've been reading and thinking about trusses a lot lately, but I decided to get my nose out of the books and collect some of my own data. I took my construction skills out of the picture as much as possible and used the corner brackets that ship with the Truss Tester. These are also available as a 3D printer file on our website at www.vernier.com/vsmt-truss. These brackets really make truss construction a breeze! I simply slid them on the bottom beam of the truss, anchored them in place with a small brad, and cut the rafters to length. I hot glued the rafters together at the peak, although the truss holder tended to keep those parts together during the test. I ended up making five different angles of simple triangular trusses, ranging from 34 to 53 degrees, all with a 21 cm base. I tested each truss, noted the maximum force required for it to fail, and plotted this data.



My data indicate that there is an optimum angle—not too steep and not too shallow. I also observed that most of my trusses seemed to buckle rather than pull apart or push together. In my next redesign, I started with a 40 degree truss angle and added some mid-rafter supports.

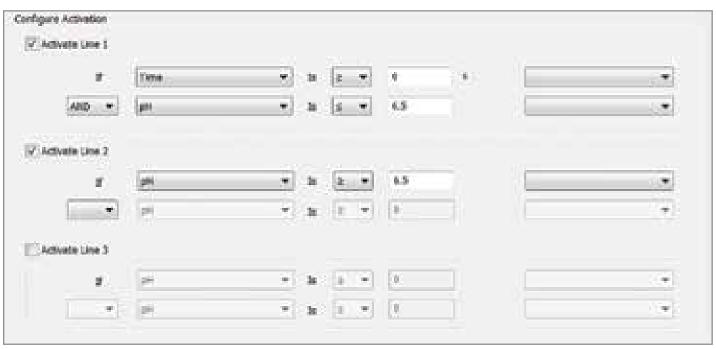
View activities associated with the VSMT and Truss Tester Accessory at www.vernier.com/vsmt

Two Engineered Solutions to Automated Titration

DCU-BTD, $61

Scientists engaged in research are also often engineers. Consider the engineering that went into developing your lab equipment, such as your force sensor and auto-titration equipment.

Are you interested in helping your students take on an engineering activity such as automating a titration? You'll find this activity among our Engineering Extension Activities (see www.vernier.com/engineering/science-classrooms/extensions). The automated titrator described in the extension activity monitors the pH of an acidic solution as a base is added via a standard buret. A Digital Control Unit (DCU-BTD, $61) is programmed in Logger *Pro* to activate a Servo Motor that opens the valve on a buret at low pH values. Once the acid is neutralized, it closes the buret. This feedback loop can be fine tuned to adjust for a different target pH, among other considerations.



Configuring the DCU via the Digital Out dialog box: Line 1 closes the buret at the target pH, Line 2 turns on an LED

Check out this project, along with other engineering extensions for your science classrooms, at www.vernier.com/engineering/science-classrooms/extensions

A similar, more advanced project is mentioned in the "Vernier in the Chemistry Journals" section (see page 9). Famularo, Kholod, and Kosenkov published an article in the *Journal of Chemistry Education* in which they describe a recent project in an upper-level instrumental analysis lab class where students created their own automated titrator devices. The article describes how the students built their own automated titration system using Vernier pH Sensors, Arduino microcontrollers, and off-the-shelf solenoid valves. In the end, they succeeded not only in building an automated titrator but also at controlling it over the Internet!

At Vernier, we applaud efforts like this that help students understand how our sensors and equipment work. When students look under the hood of their laboratory instrumentation and learn what makes something tick, they gain a better understanding of both the science they are investigating and the tools they are using.

Winners of the Vernier $5,500 Engineering Grant

Vernier Software & Technology sponsors a contest for educators who creatively use Vernier sensors to introduce engineering concepts or engineering practices. The prizes for the winners include $1,000 in cash, $3,000 in Vernier technology, and $1,500 toward expenses to attend either the NSTA STEM conference or the ASEE conference.

Congratulations to the 2015 Winners!

Carol Hsu, an instructor and College Department Chair of Engineering and Physics at Clark College, Vancouver, WA, has her students create and develop the rules for an engineering design competition every quarter. For fall 2015, students were tasked with building a bridge out of a single material to span a specified gap and to support a given load with a maximum deflection restriction of 3 cm. They used the Vernier Structures & Materials Tester with Logger *Pro* software for the competition. Each engineering class was given a different emphasis that aligned with the course materials. For example, the statics class focused on truss structure calculations. Some teams used 3D modeling software to design and analyze their bridge structures. One team used 3D printers to print the beams of their bridge. All students were required to demonstrate their understanding of the engineering design process.

Linda Rost, a biology and chemistry teacher at Baker High School, Baker, MT, wanted to integrate engineering into her science classroom, along with all three dimensions of NGSS: Disciplinary Core Ideas, Science and Engineering Practices, and Cross Cutting Concepts. She challenged her students to design and test a water filter that could lower turbidity and correct low pH and high salinity. Each group was divided into subgroups of either scientists or engineers. The scientists tested each filtered sample to determine the effect on the three parameters (turbidity, pH, and salinity). The engineers used the information the scientists provided in order to design their filter. They produced and tested three prototypes.

Honorable mention goes to the following teachers

Mario Gomes at Rochester Institute of Technology, Rochester, NY, for his Forced Response of a Rigid-Body Pendulum activity in his third-year undergraduate Mechanical Engineering "Engineering Applications Lab."

Jeremy Peterson of Northern Lakes Regional Academy, Rice Lake, WI, had students send a helium balloon into the stratosphere so they could learn about environmental gasses and open-source hardware.

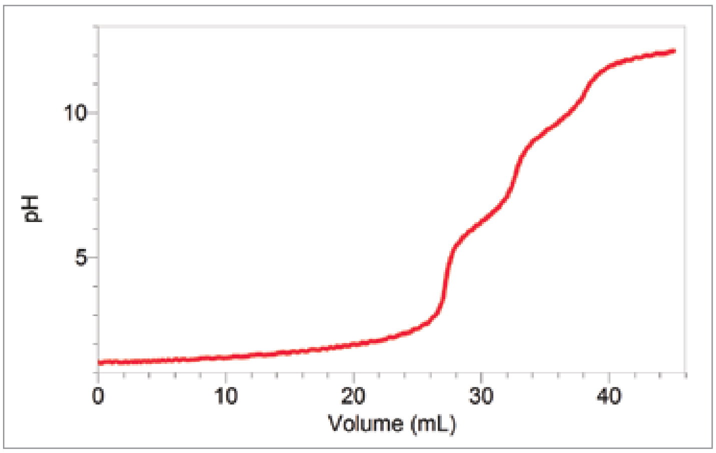
Linda Rost at Baker High School, Baker, MT, is the high school winner and also receives honorable mention for her second entry where she had her biology students create solar cells using extracted pigments from plants and berries.

For details about the contest and to see videos of the winning entries, visit www.vernier.com/grants/engineering

Interested in submitting an application of your own next year? Applications are due January 15, 2017.

NEW Biochemistry Resources for Vernier Technology

Our college chemistry resources continue to grow and now include biochemistry. Our new Biochemistry section of the Vernier website provides a list of recommended Vernier products and experiments from various Vernier lab books applicable to a biochemistry laboratory. We have also added new experiments written specifically for biochemistry, available as free downloads. The lab experiments include relevant topics and use Vernier sensors and instruments, such as the Tris-Compatible Flat pH Sensor (FPH-BTA, $99) and the Vernier UV-VIS Spectrophotometer (VSP-UV, $1999), to teach students important concepts, techniques, and the appropriate use of instruments for biochemistry experiments. Each download includes a student lab handout, instructor information for preparing reagents, hazard information for chemicals used, and sample data.



Acid-base titration of L-histidine

One of the new experiments uses acid-base titration to explore the acidic and basic properties of amino acids. Amino acids contain ionizable groups and are categorized according to their interaction with water. The ionic form of these molecules in water depends on the pH, so a titration of an amino acid demonstrates the effect of pH on amino acid structure. It is also useful in determining the reactivity of amino acid side chains.

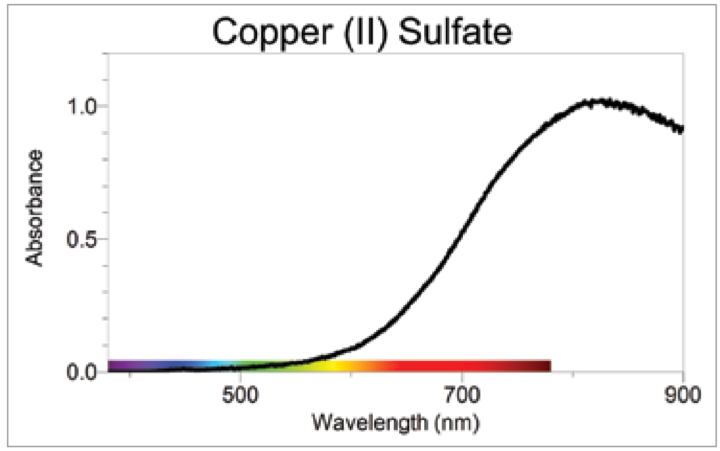
All of these resources can be found at www.vernier.com/biochemistry

How does a Colorimeter Compare to a Spectrophotometer?

We frequently talk with teachers who wonder if they should invest in a spectrophotometer or if they can run an experiment successfully with the more affordable colorimeter. Let's compare the two devices to clarify these options.

A spectrophotometer can be set to measure % transmittance or absorbance over a wide range of wavelengths. For example, the wavelength range of the SpectroVis Plus Spectrophotometer (SVIS-PL, $399) is 380 nm to 950 nm, and the wavelength interval is approximately 1 nm between reported values. In comparison, the Vernier Colorimeter (COL-BTA, $115) can measure % transmittance and absorbance at four specific wavelengths (430, 470, 565, and 635 nm) produced by internal LEDs.

Many of the same experiments will produce valid results on either device. For example, if you are doing an experiment based on Beer's law (absorbance *vs.* concentration), both devices will give you a direct relationship between the absorbance value and the concentration of the standard solutions. Subsequent determination of the concentration of an unknown solution, based on the standards, will produce similar results.



Absorbance spectrum of copper (II) sulfate using SpectroVis Plus

Deciding to purchase a colorimeter or a spectrophotometer depends on the types of experiments in your curriculum. A spectrophotometer is compatible with all the spectroscopy experiments in the Vernier chemistry lab books. Several of those same experiments include instructions for use with a colorimeter. Many of the AP* chemistry lab experiments from the College Board emphasize the importance of a spectrophotometer's ability to measure a full absorbance or % transmittance spectrum.

	SpectroVis Plus	Colorimeter
Wavelength options	380 to 950 nm	430, 470, 565, 635 nm
Absorbance *vs.* concentration	Yes	Yes
Absorbance *vs.* time	Yes	Yes
Absorbance *vs.* wavelength	Yes	No
Connection type	LabQuest interface and computer USB port	LabQuest interface and Vernier computer interfaces
Order code	SVIS-PL	COL-BTA
Price	$399	$115

Vernier offers a range of affordable educational spectrophotometers. For more information, visit www.vernier.com/spectrometers

Vernier in the Chemistry Journals

Variations on the "Blue-Bottle" Demonstration Using Food Items That Contain FD&C Blue #1

Felicia A. Staiger; Joshua P. Peterson; and Dean J. Campbell; *J. Chem. Educ.* 2015, 92, 1684–1686.

Featured: LabQuest 2 and Colorimeter

Improvements to the Whoosh Bottle Rocket Car Demonstration

Dean J. Campbell; Felicia A. Staiger; and Chaitanya N. Jujjavarapu; *J. Chem. Educ.* 2015, 92, 1687–1691.

Featured: LabQuest 2, Surface Temperature Sensor, Low-g Accelerometer, and Dual-Range Force Sensor

Studying Cooperative Ligand Binding in the Undergraduate Biochemistry Laboratory: Oxygen–Hemoglobin Dissociation Revisited

Megan K. M. Young and Theodore J. Gries; *J. Chem. Educ.* 2015, 92, 2173–2175.

Featured: Vernier Gas Pressure Sensor

Integrating Chemistry Laboratory Instrumentation into the Industrial Internet: Building, Programming, and Experimenting with an Automatic Titrator

Nicole Famularo; Yana Kholod; and Dmytro Kosenkov; *J. Chem. Educ*, 2016, 93, 175–181.

Featured: Vernier pH Sensor

Kinetics, Reaction Orders, Rate Laws, and Their Relation to Mechanisms: A Hands-On Introduction for High School Students Using Portable Spectrophotometry

Jack M. Carraher; Sarah M. Curry; and Jean-Philippe Tessonnier; *J. Chem. Educ.* 2016, 93, 172–174.

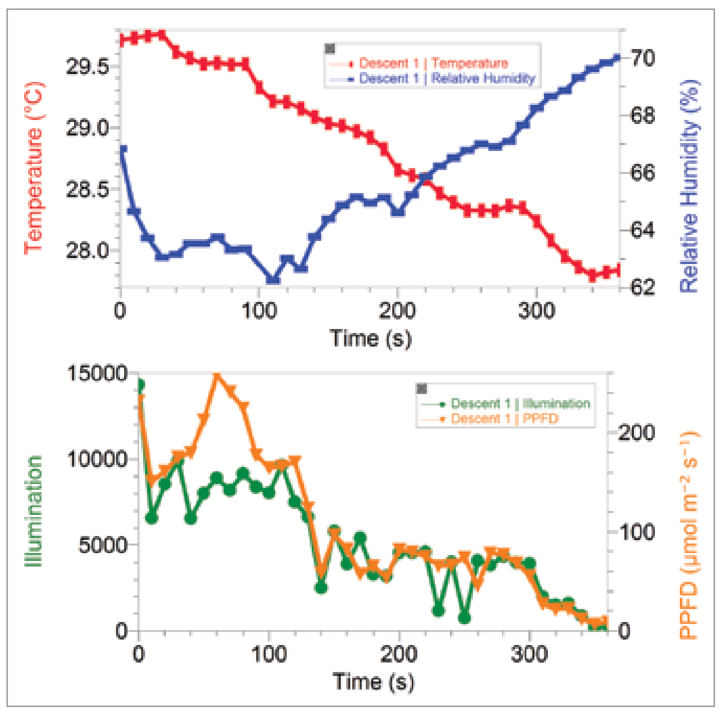
Featured: LabQuest and SpectroVis Plus Spectrophotometer

An Amazon Adventure Using LabQuest 2

By Phil Kahler, Tualatin Valley Academy, Hillsboro, OR

On July 7, 2015, while participating in the Educator Academy in the Amazon Rainforest, I conducted an exciting data-collection study at the Amazon Conservatory of Tropical Studies (ACTS) in Peru to learn how microclimates change at each vertical layer of a tropical rainforest. The initial idea was an ambitious one—lower a LabQuest 2, a Stainless Steel Temperature Probe, a Relative Humidity Sensor, a PAR (Photosynthetically Active Radiation) Sensor, and a GoPro® camera from a walkway in the canopy 24 m above the forest floor to collect video paired with data for simultaneous visual and graphical analysis.

The data show that the highest temperature and lowest relative humidity values occurred at the rainforest canopy layer. As the LabQuest 2 was lowered through the understory down to the forest floor, the temperature decreased slightly while the relative humidity rose. We also saw a dramatic difference in light levels between the canopy and the understory. As the LabQuest 2 passed through the understory, sudden decreases and increases in illumination were observed. This was likely due to variation in the canopy cover.



Temperature, relative humidity, PAR, and illumination measured while descending through the layers of an Amazonian rainforest

This project allowed us to see firsthand the relationships between the abiotic and biotic factors that make the Amazon a treasure trove of biodiversity. Armed with photographs, personal stories, and data, I have begun to impress upon my students the importance of preserving this faraway place. It is one thing to read and talk about what's going on in a rainforest and quite another thing to see it first hand.

For more information about this study and the Educator Academy in the Amazon Rainforest, see www.vernier.com/r164

Environmental Science

Can Adding a Nose Cone Improve Turbine Efficiency?

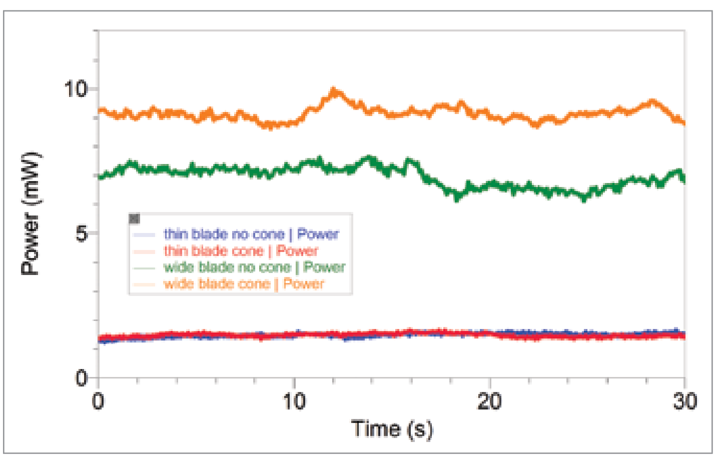
After reading about engineers at GE experimenting with nose cones to improve wind turbine efficiency (see www.vernier.com/r169), we decided to design and test our own nose cones on a KidWind Wind Turbine (KW-BWX, $109). One of our engineers created two different spherical-cap-shaped nose cones in a CAD program and printed them on a 3D printer. The nose cones were designed to fit onto the KidWind Wind Turbine Hub by fitting over the T-bolt and holding on with friction.

We designed a series of experiments to test the effect of the presence and shape of a nose cone under a wide range of conditions, including variations in wind speed, blade shape, and blade pitch:

Wind speed	Blade shape	Blade pitch
Three speed settings on a Lasko, 20-inch square fan: high, medium, and low	Two rectangular blades: 1 inch × 9 inch and 3 inch × 6 inch	10°, 20°, and 30°

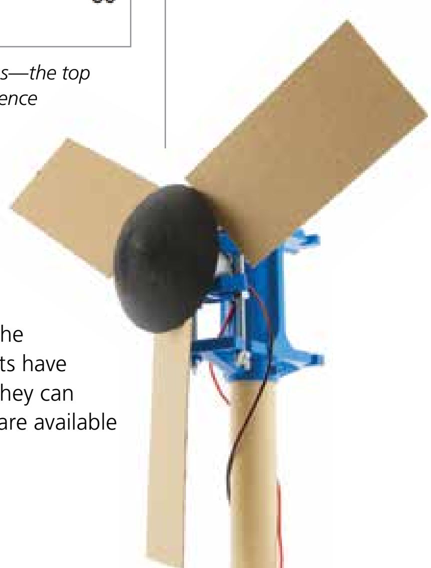
In the majority of our tests, the difference in energy generated with and without the nose cones was non-existent, or within the uncertainty values of the measurements. This was a disappointing, but meaningful, finding.

However, there was one set of trials that showed a significant difference when the nose cone was attached. At the highest wind speed, a load of 51 Ω, and the 3 inch × 6 inch blades at a 30° angle, the turbine produced an average of 7.0 ± 0.1 mW without the nose cone and an average of 9.16 ± 0.09 mW with the 4-inch-diameter nose cone—an increase of about 30%.



Four representative data-collection runs with and without nose cones—the top two traces represent the trials where we observed the biggest difference in power generation; the bottom two traces show no significant difference.

Right: Three-bladed wind turbine with 4-inch spherical cap nose cone

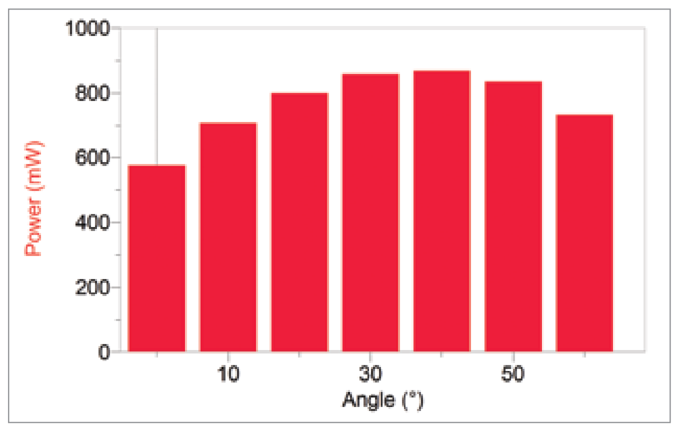


You and your students can do a similar experiment. If you don't have access to a 3D printer, you can use hemispheres of expanded polystyrene from a craft store, which is what the GE engineers used for their early prototypes. If your students have experience with CAD software and access to a 3D printer, they can design their own nose cones or modify our designs, which are available for 3D printing at www.thingiverse.com/vernier

Investigating Solar Panel Output

The solar industry is in the midst of a rapid period of growth. According to The Solar Foundation's 2013 National Solar Jobs Census, employment in the solar industry has grown by 53% since 2010. The Solar Foundation's study went on to report that one in every 142 new jobs in the United States was created by the solar industry. While solar panel technology has a long way to go, researchers are presently developing more energy-efficient solar cells, and the cost for new technologies is declining. Engaging students in meaningful, hands-on learning experiences is a step in preparing students to participate in the opportunities available in the growing solar industry.

Experiments such as "Effect of Load on Solar Panel Output" and "Effect of Temperature on Solar Panel Output" from our *Renewable Energy with Vernier* lab book (REV, $48) introduce students to how load and temperature affect the power output of solar panels. The "Variables Affecting Solar Panel Output" experiment from the same book challenges students to design an experiment to test a variable of their choosing. Using the new Solar Energy Exploration Kit (KW-SEEK, $50), with its hinged box and hook-and-pile fasteners that hold multiple solar panels in place, students can easily develop and carry out an experiment to discover how the angle of photovoltaic panels relative to the sun affects power output.



The effect of angle on the power output from three KidWind 2V Solar Panels

Download "Variables Affecting Solar Panel Output" at www.vernier.com/r165

Science Humor

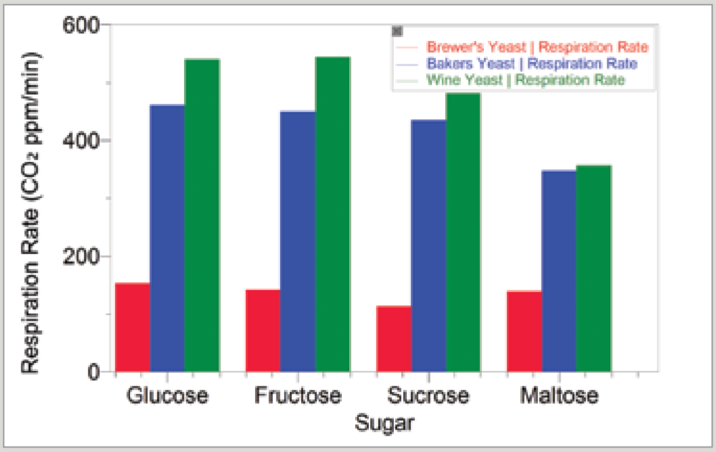
A chemist goes into a pharmacy.
Chemist: Hey, do you have any of that isobutylphenylpropanoic acid?
Shopkeeper: You mean Advil?
Chemist: Yeah, that's it. I can never remember that name.

Q: What is the volume of a cylinder of radius *z* with a height of *a*?
A: Volume = pi *z z a*

I have a new theory on inertia, but it doesn't seem to be gaining momentum.

Use a CO_2 Gas Sensor to Study Artificial Selection in Yeast

Yeast are very important microorganisms that have been used by human cultures for centuries. Over time, humans have had a hand in yeast evolution through artificial selection while developing different strains of yeast for a range of functions, including baking and brewing. You can use our CO_2 Gas Sensor (CO2-BTA, $259) to perform the "Evolution of Yeast" activity in *Investigating Biology through Inquiry* (BIO-I, $48) as a simple way to demonstrate the result of evolution due to artificial selection. Flinn Scientific, Inc. has made it even easier to conduct this investigation by offering a guided inquiry kit, "The Evolution of Yeast with a CO_2 Gas Sensor" (Flinn Catalog No. FB2128). The kit, which contains enough materials for 30 students in an inquiry setting, includes three strains of yeast and four different sugars, enabling students to study how different yeast strains process various types of sugar. Aligned to NGSS, this kit, along with Vernier technology, will help engage your students in scientific exploration.



Respiration rate of different yeast strains fed different types of sugar

For more information about this investigation or our *Investigating Biology through Inquiry* lab book, visit www.vernier.com/bio-i

Ecology/Environmental Science Teaching Award Winner Announced

Kelly Mandy of Marist School in Atlanta, Georgia, was the 2015 recipient of the NABT Ecology/ Environmental Science Teaching Award. This award, sponsored by Vernier, was presented at the 2015 NABT Professional Development Conference in Providence, RI. Mrs. Mandy is a seventh grade science, environmental science, and ninth grade biology teacher who uses the outdoors as an extension of her classroom. Each week, her students perform water quality tests in nearby Nancy Creek and submit results to Georgia Adopt-a-Stream, making the students directly involved in the monitoring of Georgia's waterways. Mrs. Mandy's students also design projects based on the work completed by her previous classes, which allows students to contribute in a short period of time to large-scale projects like the clearing of invasive Chinese Privet from Nancy Creek.

The NABT Ecology/Environmental Science Teaching Award is given to a secondary school teacher who has successfully developed and demonstrated an innovative approach in the teaching of ecology/ environmental science and has carried his/her commitment to the environment into the community. Our sponsorship of this award includes $500 toward travel to the NABT Conference and $1,000 of Vernier equipment. The recipient also receives a recognition plaque and one year of complimentary membership to NABT. The application deadline for the Ecology/Environmental Science Teaching Award is March 15 of each year. While it has just passed for 2016, start thinking about applying in 2017. Applications will be available after the NABT Conference in November. You can find more information about this award at www.nabt.org

NEW ProScope 5MP Microscope Camera

BD-PS-MC5UW, $299*

* Microscope, iPhone, and Android device not included

Why buy brand new microscopes when you can simply update your current microscopes with innovative imaging technology? Our newest camera, the ProScope 5MP Microscope Camera, conveniently replaces the eyepiece of your microscope and connects to iOS and Android devices via Wi-Fi or directly to a computer or Chromebook via USB. Once connected, a live image of the current view through the microscope will be displayed. Capture still images and record short videos using a free app on mobile devices and Chromebooks or Logger *Pro* on a computer. Included with the ProScope 5MP Microscope Camera is a mount for a mobile device, two eyepiece adapters to ensure it fits into your microscope, a USB cable, and a power adapter. With a fast response time and high resolution, it produces very clear images that are easy to display, save, and incorporate directly into lab reports. For more information, visit www.vernier.com/bd-ps-mc5uw

Logger *Pro* Power User Features

Are you looking for ways to expand your use of Logger *Pro*? Here are tips to get you started with some of the advanced features of our powerful data-collection and analysis software:

1 Add multiple pages within a single Logger *Pro* file to organize graphs, data tables, pictures, and other information. All pages share the same underlying data and data-collection settings. See the Page menu for options.

2 Combine data from several files into one by choosing Import from ▶ Logger *Pro* File from the File menu. You can use this feature to easily compare data from multiple groups.

3 Choose Strike Through Data Cells from the Edit menu to temporarily ignore some data points. This is a great way to remove selected data from graphs or curve fits without actually deleting the values. The values are shown with a line through them in the data table. The feature can be used to ignore preliminary motion detector data, for example.

4 When the graph is selected, you can use the spacebar to start or stop data collection. No more hunting for the Collect button.

5 Draw predictions before doing experiments. To do this, choose Draw Prediction from the Analyze menu.

6 Add a second vertical axis to display data of incommensurate units on the same graph. For example, graph pH and the derivative of pH on a single graph. Choose Graph Options from the Options menu to enable and configure a second y-axis.

7 Choose Model from the Analyze menu to plot functions on a graph; then, adjust the parameters in the function helper object by selecting the parameter and using the arrow keys or by selecting the value of the parameter and entering values by typing on the keyboard or using cursor keys. Use this feature to have students find their own best-fit line and then compare it to the least-squares fit.

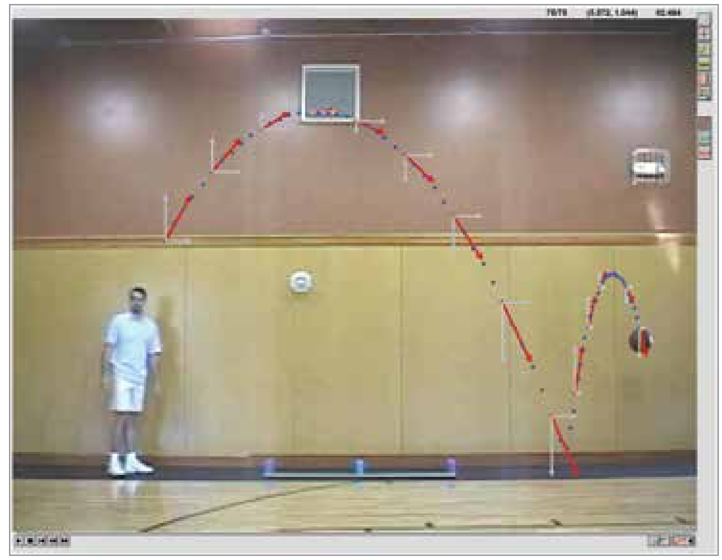
8 Use calculated columns to display inferred quantities, even during data collection. For example, graph kinetic energy using a calculated column of 1/2 mv^2 from the Motion Detector velocity data. Use a user parameter for *m* while you're at it, and then add a parameter control for *m* using the Insert menu.

9 Show error bars on a graph; error bars can be a fixed fraction, fixed value, or independently entered values. Enable error bars by choosing Column Options from the Data menu.

10 Create a semi-log or log-log graph by choosing Graph Options from the Options menu.

Animated Displays in Logger *Pro*

One of the great, hidden features of Logger *Pro* is the ability to add vector displays to motion you are studying. Two sample files that use this feature are included with Logger *Pro*. One of the files, "Basketball Shot vector analysis," can be found in the "Sample Movies" folder. If you open the file and play the movie, the vectors appear on the movie as the ball moves.



Velocity vectors in Logger Pro

For a tutorial on how to set up animated displays in your Logger *Pro* files, choose Open from the File menu and navigate to the "Exploring Animated Displays" file in Sample Data > Physics > Animated Display Vectors.

Software Updates

We regularly release software updates to add new features, support new sensors and operating systems, and to fix the occasional bug. Keeping up to date with software releases is one way to keep things running smoothly in your classroom or lab. Have you updated your Vernier applications in the last few months? We've updated nearly all our titles since the last newsletter—some several times.

Download updates for computer and LabQuest software directly from our website and find links to the appropriate app stores for updates to Chrome, iOS, and Android applications: www.vernier.com/downloads

Note that with an account on the Vernier website and a purchase history of Logger *Pro*, you can download the Logger *Pro* full installer at any time—you don't have to wait for a CD or download link. Give the installer to your students to install on their home computers or provide it to your IT department.

Spotlight on Past Vernier Award Winners

Ann Shioji

2015 Vernier/NSTA Technology Award Winner

Students at Overfelt High School investigate the effect of several chemicals on yeast growth

Ann Shioji, a chemistry teacher at Overfelt High School in San Jose, CA, is passionate about using technology to teach her students how chemicals affect their daily lives. As a 2015 Vernier/NSTA Technology Award winner, Shioji uses SpectroVis Plus Spectrophotometers to help students conduct research for her "Beauty and the Yeast" unit. She said implementation of the lesson would not be possible without Vernier technology.

"Yeast is a single-celled organism, and while it can be counted using serial dilutions and microscopes, these methods are not as reliable as the in-situ experiments that the use of a SpectroVis Plus allows," Shioji said. "The greatest impact was that students did not become inundated with procedures, but rather they were able to apply an experimental design efficiently."

The SpectroVis Plus speeds up the data-collection process, allowing students to complete a lab that usually takes two days, in a matter of minutes. At the beginning of the lesson, students conduct preliminary research on the gestation period and respiration rates of yeast and perform a class investigation. They then design their own inquiry-based experiments using SpectroVis Plus to measure how an independent variable of their choosing affects yeast growth.

The students were eager to enter upcoming science fair competitions and conduct multiple trials to determine the effect of several chemicals on yeast growth. For their efforts, they were recognized as the "School with the Best Science Fair Projects" at their district science fair.

To learn more about Ann Shioji's use of Vernier products, visit www.vernier.com/r166

Ashley Webb

2014 Vernier/NSTA Technology Award Winner

Students at DeSoto Central High School launch a water-propelled rocket

Ashley Webb, a 2014 Vernier/NSTA Technology Award winner, engages her physics and chemistry students at DeSoto Central High School in Southhaven, MS in hands-on learning as much as possible. "Using the technology acquired through the award, my students have the opportunity to transform ambiguous concepts into tangible ideas through hands-on data collection," said Webb. "The technology supports guided inquiry and works masterfully for my visual and kinesthetic learners."

The Vernier technology—including various sensors, LabQuests, and the Graphical Analysis and Video Physics apps—is used, in part, during the high school's "Creating Leaders in STEM" program, which provides innovative opportunities for AP Physics and AP Environmental Science students to review for their AP tests while helping younger students engage in STEM education.

During the program, the high school physics students conduct inquiry-based investigations using Vernier technology to introduce 6th grade students at the school's feeder school to Newton's three laws of motion. The high school students then assist the groups as they participate in an engineering design challenge, which involves building and launching a water-propelled rocket.

"Students use the Vernier sensors and apps to collect data to describe the mechanics of their rocket—from Newton's third law to the Impulse-Momentum Theorem to the idea of conservation of mechanical energy," said Webb.

As a result of the program, Webb's high school students strengthen their conceptual understanding of physics while helping to spark an interest in STEM education for the younger students.

To learn more about Ashley Webb's projects, visit www.vernier.com/r167

Larry Beall

Vernier 30th Anniversary Grant Winner

A student at Central Campus uses Vernier technology to test water quality

Larry Beall, a science teacher at Central Campus High School in Des Moines, IA and the director of the high school's Iowa Energy & Sustainability Academy (IESA), is a true believer in hands-on learning. "My philosophy, as well as the philosophy of IESA, is that science is all about seeing and doing," said Beall. "You can't just talk to students about various principles and concepts; you have to truly immerse them in the scientific discovery process."

IESA is a two-year program in which students receive both high school and college credit by participating in unique field experiences and in-depth studies of various energy and sustainability topics. Such field activities include testing water, air, and soil samples at the Des Moines River, tours of the nearby water treatment facility, and much more.

As a winner of the Vernier 30th Anniversary Grant, Beall has been able to use data-collection technology to further support IESA students' hands-on investigations both in the classroom and in the field. In one such investigation, students use LabQuest, as well as a variety of Vernier sensors—including the Dissolved Oxygen Probe, Turbidity Sensor, pH Sensor, Stainless Steel Temperature Probe, and more—to study the hydrologic cycle and test how farming, lawn care, and other issues contribute to water quality.

"After conducting preliminary research, students collect and analyze water samples from the river, draw conclusions, and then present their findings," said Beall. "The Vernier technology is instrumental in these investigations—it is not only easy to use, but extremely durable, which has been a key factor for us."

To learn more, visit www.vernier.com/r168

Award Winners

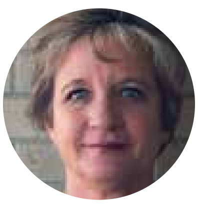
Vernier/NSTA Technology Award Winners 2016

Elementary School

Sherie Ryan-Bailey
Oakley Elementary School, Asheville, NC

Using Vernier probes, a weather station, and resources from a local university, Sherie Ryan-Bailey's fifth grade students learn weather patterns and how different factors influence weather conditions in their area. As part of the activity, students study micro-climates in their schoolyard, exploring which locations are the wettest, hottest, or coolest. They then analyze the data on their own devices through the school's 1:1 initiative.

Middle School



Greer Harvell
Walton Middle School, Defuniak Springs, FL

Greer Harvell's seventh grade students will use Vernier's probeware to act as "citizen scientists" and monitor the water quality of a lake located less than a block from their middle school. Harvell says Lake Defuniak is a focal point of the rural community, but it is not monitored by local organizations. Students will measure dissolved oxygen, pH, total dissolved solids, and temperature at different depths.

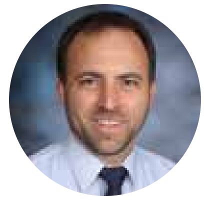
Aaron Mueller
Scullen Middle School, Naperville, IL

Aaron Mueller, a middle school science teacher in suburban Chicago, believes all students should examine the implications of modern development in their communities. Aaron's cross-grade level collaborative project encourages students to use Vernier probeware to explore the causes of non-point source pollution in retention ponds and natural waterways near their school.

High School

Richard Erickson
Bayfield High School, Bayfield, WI

Richard Erickson and his students spend the school year investigating the seiches in Lake Superior, a standing wave oscillation created by atmospheric forces. When a weather event is imminent, the high schoolers—equipped with Vernier Motion Detectors—examine the lake's water level, then mount detectors to the deck of a nearby boathouse. The detectors record changes in the lake's water level for the next seven days, and students analyze the subsequent data to formulate mathematical models of seiche behavior.



Dan Starr
Green Lake School, Green Lake, WI

Students at Green Lake School in Wisconsin plan to expand their studies of the natural inland lake near their school, which is suffering from poor water quality. Led by instructor Dan Starr, the students will use Vernier data-collection technology to study the Big Green Lake's water resources, and determine which management decisions are necessary to improve the watershed.

Ben Smith
Peninsula High School, Rolling Hills, CA

Ben Smith believes there are still too many questions about the role ants and termites play in our ecosystem. His project at Peninsula High School in Rolling Hills, CA encourages students to launch inquiry-based field and laboratory investigations that explore the relevance of these insects to fundamental ecological issues. Students study spatial and temporal patterns, biogeography, microclimate, and species diversity as part of the school's environmental program.

College

Kasey Wagoner
Philadelphia University, Philadelphia, PA

Kasey Wagoner, a physics professor at Philadelphia University, wants to improve attitudes toward physics. He's creating a project-based physics course for non-science majors that will incorporate Vernier probes and software. To support autonomy, Wagoner says students will have the freedom to develop their own projects related to three traditional physics subject areas: forces and motion, energy and momentum, and waves and oscillations.

Vernier Named Finalist for Global Award

GESS
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2016

The Global Educational Supplies & Solutions (GESS) named Vernier Software & Technology as a finalist for Best Multi-National Company of the Year. The association also honored Graphical Analysis for iOS, Android, and Chrome as a finalist for Best Free App / ICT Product.

This award reflects our commitment to providing educators in over 130 countries with innovative products and extraordinary educator support.

Professional Development

Hands-On Summer Institutes

Most schools may close for the summer, but the learning never stops at Vernier. Join us for a full-day exploration of Vernier's award-winning line of computer and handheld data-acquisition technology. You'll leave the workshop ready to enhance your students' learning with data collection.

The cost of the institute is $99, which includes a lab book of your choice (a $48 value). Please see the website for Training Package pricing. The registration form can be found at www.vernier.com/summer-institutes

AZ	Phoenix 6/20	NY	Long Island 7/13
CT	Hartford 7/11	OR	Beaverton 8/3
GA	Atlanta 6/13	TN	Nashville 6/17
IA	Des Moines 6/30	TX	El Paso 6/23
KY	Lexington 6/15	WA	Seattle 8/5
MD	Baltimore 7/15	WI	Milwaukee 6/27

One-Day, Subject-Specific Institutes

Held in Beaverton, OR, at the Vernier Office

Engineering for Science Classrooms Institute

For intermediate users who have some experience using Logger *Pro*

June 29, 2016

The $99 registration fee includes lunch and a Vernier Digital Control Unit, a $61 value.

Vernier Sensors with Arduino™ Institute

For intermediate users

June 30, 2016

The $99 registration fee includes lunch, a SparkFun Arduino RedBoard, and a Vernier Interface Shield, a $50 value.

Two-Day, Subject-Specific Institutes

Held in Beaverton, OR, at the Vernier Office

Biology Institute

July 22–23, 2016

The $199 registration fee includes lunch and a copy of the lab book, *Investigating Biology through Inquiry*, a $48 value.

Chemistry Institute

July 18–19, 2016

The $199 registration fee includes lunch and a copy of a Vernier chemistry lab book of your choice, a $48 value.

Environmental Science Institute

July 20–21, 2016

The $199 registration fee includes lunch and a copy of the lab book, *Investigating Environmental Science through Inquiry*, a $48 value.

Physics Institute

June 27–28, 2016

The $199 registration fee includes lunch and a copy of the lab book, *Physics with Vernier*, 3rd edition, a $48 value.

You may also be able to earn graduate education credit through Portland State University.

Details and registration for all workshops can be found at www.vernier.com/training

Vernier Wins Stellar Service Award

Vernier was awarded a Stellar Service Award for Best Help Site Portal by readers of *Tech & Learning*, the premier publication for education technology leaders.

The portal, Vernier's Technical Information Library (TIL), houses an extensive library of technical information, troubleshooting advice, answers to questions frequently asked by teachers, and more than 1,000 searchable technology tips. The Vernier TIL is part of a collection of comprehensive resources that Vernier provides, which include step-by-step tutorials, a purchasing guide, Tech Tips videos produced by Vernier product developers, and free personalized training webinars for schools and districts.

The TIL is just one of many ways Vernier provides uniquely remarkable customer service. The company offers free hands-on training across the country, which allows educators to learn about probeware in a way that is fun and engaging. In addition, when you call Vernier for technical support, you will always speak to a live person. Most times, in fact, you will speak with the person who developed the product or with a fellow educator who has experience teaching with probeware in the classroom.

Vernier
Celebrating 35 Years

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