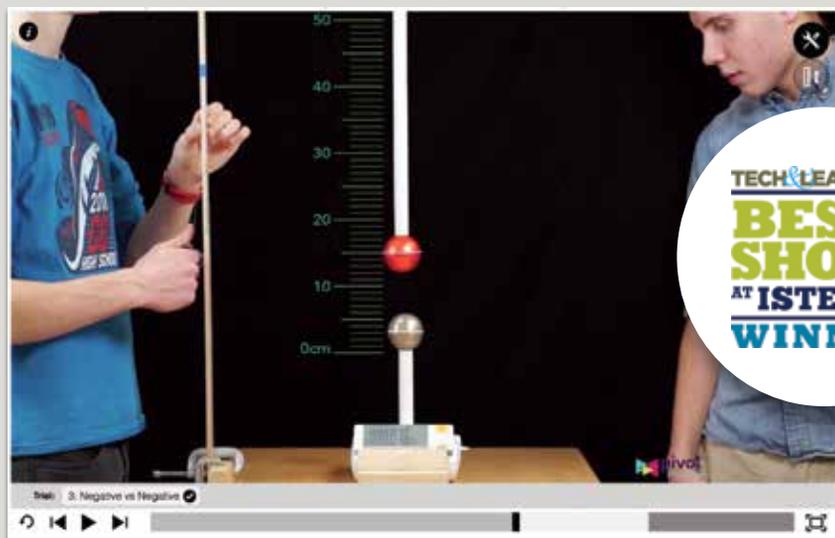


## IN THIS ISSUE

- 2 3D-Printable Eddy Current Brake for Dynamics Cart and Track System Carts
- 3 A Smart Wilberforce Pendulum
- 4 The Great American Eclipse
- 5 Simplify Arduino™ Programming with the New Vernier Library
- 6 An Inquiry Approach to Understanding the Relationship Between Dissolved Oxygen and Temperature
- 8 Mobile Teaching Laboratory Provides Inspiration Using Vernier Products
- 9 Vernier Sponsors National KidWind Challenge
- 10 Applications Open for Annual Vernier/NSTA Technology Awards
- 11 FREE Hands-On, Data-Collection Workshops

## NEW Pivot Interactives— An Online-Video Physics Tool



A ruler overlay allows separation measurements while a scale provides force information in a Pivot Interactives activity.

While we love hands-on activities, some experiments are just too hard for students to perform successfully and consistently. For example, Coulomb's law is tough in the best circumstances, so few physics instructors do more than assign homework problems on this topic. Pivot Interactives, distributed by subscription, gives teachers another way to introduce this content to students.

Pivot Interactives is a browser-based collection of videos and analysis tools that enable students to confront real phenomena (not simulations),

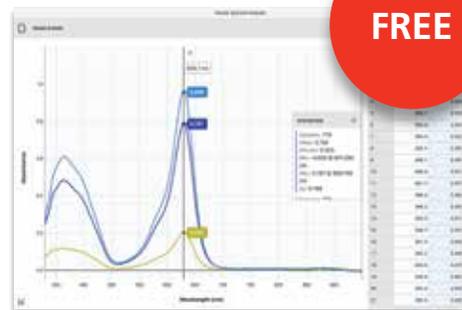
select experimental parameters, and make careful measurements. For example, the Coulomb's law activity is not a single video, but a family of videos that vary charge sign and pairing. A student chooses the experimental parameters for subsequent measurements.

In another activity, students look at longitudinal waves and can select among 50 different drive frequencies. In the classroom, it is difficult to set up experiments with transverse waves. However, these videos enable easy exploration and data collection.

Continued on next page →

## NEW Vernier Spectral Analysis™ App

FREE



Spectral Analysis is a powerful, new app that makes it easy to collect spectroscopy data with the Vernier Go Direct™ SpectroVis® Plus and other Vernier spectrophotometers. Simply connect a spectrometer, launch the app, and follow the intuitive interface to collect the following data:

- **Absorbance or % transmittance vs. wavelength data:** Generate the full spectrum of a liquid, such as a sports drink or an extraction of chlorophyll from spinach leaves.
- **Absorbance or % transmittance vs. concentration:** Conduct Beer's law experiments to determine the concentration of an unknown solution by creating a standard curve of absorbance, or percent transmittance, versus concentration.
- **Absorbance or % transmittance vs. time:** Measure the chemical kinetics of crystal violet and sodium hydroxide.

Continued on next page →

← Continued from cover

Layered tools on the videos allow spatial and temporal measurements; students must decide what to measure before doing so. Simple graphing and fitting tools allow student-driven analysis to drive quantitative understanding of what they have seen, including considerations of experimental uncertainty. Couple all this with a collection of classroom-tested, easily modifiable exercises using the videos (complete with instructor notes), and you have a new way to extend the critical thinking tools of your students.

High school licenses are \$5 per student, per year. College licenses are \$10 per student, per term, per course. Learn more about Pivot Interactives at [www.vernier.com/pivot](http://www.vernier.com/pivot)

## 3D-Printable Eddy Current Brake for Dynamics Cart and Track System Carts

An eddy current brake is a non-contact braking system, most commonly used in trains and roller coasters. In an eddy current brake, magnets are used to induce eddy currents in a metal rotor or another metal part of the vehicle. According to Lenz's law, those induced currents create a magnetic field opposing the original field. The two opposing magnetic fields work to slow the vehicle in contrast to the frictional force used in a traditional braking system.

Chris Gaffney and Adam Catching's article "Magnetic Viscous Drag for Friction Labs," in the September 2016 edition of *The Physics Teacher* describes their investigation into eddy current braking. As an alternative to a traditional friction lab, their students slide magnets down a long aluminum ramp. The magnets are slowed by the eddy currents they induce in the ramp.

As a company that sells a lot of aluminum dynamics tracks, it seemed natural for us to try this out. We designed and 3D-printed a simple magnet holder for our plastic Dynamics Cart and Track System (DTS) carts. It holds up to four magnets about 2 mm off the surface of the dynamics track.

The graph shows the velocity of a DTS cart rolling on an inclined track, with either the eddy current brake (zero, two, or four magnets) or our Friction Pad (DTS-PAD) installed. With zero magnets, the cart's velocity increases linearly, as expected. With the Friction Pad installed on the cart, the velocity curve is similarly linear—albeit with a shallower slope.



■ Eddy current brake installed on DTS cart

← Continued from cover

After data collection is complete, built-in curve fits and statistical-analysis tools allow your students to quickly analyze their data. They can also easily create calculated columns to accurately determine chemical reaction order. Once analysis is complete, students can save or export their data in a variety of ways to share data with their peers or create a lab write-up for submission.

Spectral Analysis for Chromebook™ is available in the Chrome Web Store. Visit [www.vernier.com/downloads](http://www.vernier.com/downloads) to download Spectral Analysis for your macOS® or Windows® computers. Versions of Spectral Analysis for iOS® and Android™ will be available in the future. For more info, visit [www.vernier.com/spectral-analysis](http://www.vernier.com/spectral-analysis)

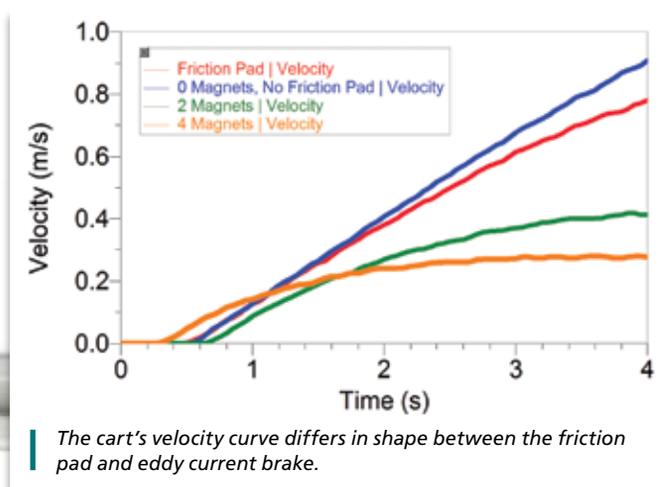
The shape of the velocity curve differs when the eddy current brake is installed. As expected, the induced drag on the cart increases with the number of magnets installed. It is also apparent that the nature of the eddy current braking force is different than simple kinetic friction. For example, with four magnets installed the cart reaches terminal velocity within four seconds.

The coefficient of friction, a measure of how easily two surfaces slide past one another, depends on the surfaces in contact and the normal force on the cart. In this case, the normal force is determined by the weight of the cart and the angle of the track. Neither factor varies, so kinetic friction is constant during the motion down the ramp. Thus, the velocity increases steadily, much as it would without the Friction Pad, but at a lower rate.

However, the model for the induced magnetic drag on the cart depends on the velocity of the cart. The faster the cart moves, the greater the induced eddy currents and the greater the drag. At terminal velocity, the drag has increased to the point that the acceleration of the cart drops to zero.

If you would like to investigate eddy current braking with DTS carts and tracks, you can 3D print your own brake. You will find the design on our Thingiverse page:

[www.vernier.com/r1716](http://www.vernier.com/r1716)



## A Smart Wilberforce Pendulum

By Keith Clay,  
Green River College

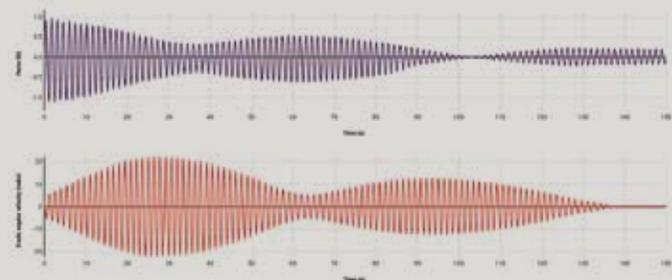
A Wilberforce pendulum is a physics toy that would drive Iron Man to distraction. Simply put, it is a mass tightly attached to the end of a spring that can oscillate up and down *and* twist back and forth. If the vertical and twisting motions have similar frequencies, the pendulum repeatedly alternates between the two,



The pendulum stands six meters high, top to bottom.

twisting side to side and then bobbing up and down as energy is passed between vertical and rotational motion.

At Vernier, we recently built a Wilberforce pendulum using a Go Direct™ Force and Acceleration Sensor, a Rotary Motion Accessory Kit, and a metal Slinky®. We used Graphical Analysis 4 to receive and graph data from the Go Direct Force and Acceleration Sensor. The sensor uses an internal gyro to track the rotation and uses the onboard accelerometer or force sensor to track the vertical motion. It beautifully displays the beats of an oscillator with two normal modes.



Force and rotational motion data were collected from the tabletop Wilberforce pendulum using Graphical Analysis. The exchange of energy between vertical and rotational modes of motion can be seen in the interplay of measured force and rotational velocity.

The data shown here were collected from a tabletop version made with a sensor, a lab spring, and washers, nuts and bolts to tune the inertia. We also built a pendulum six meters high using a Slinky for the spring and a Rotary Motion Accessory Kit in place of the bolts and washers.

A Wilberforce pendulum provides great opportunities for exploration. You can ask students to measure the moment of inertia or the torsional spring constant. Challenge students to name and measure five relevant forms of potential and kinetic energy. Or simply watch as it goes through its graceful dance, dutifully graphing the motion.

## AAPT Photo Contest

The 2017 AAPT Photo Contest, sponsored by Vernier, was held at the summer meeting of the American Association of Physics Teachers in Cincinnati, Ohio. Students submitted photos that demonstrate physics concepts, along with essays that explain them. AAPT members voted on the entries. Each year we are impressed by the creativity of the students who enter this contest. The eye-drawing composition of these images reminds us that art has both an important role in our lives and a valuable connection to science.



The winner in the Contrived Category is Ryan Michael Brohm for the photo “Smile for the Camera!”



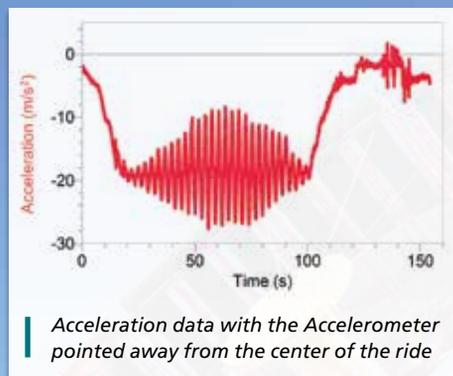
Kyle Douglas Willette won the Natural Category with the photo “The Balance of Nature.”

For details about the contest and to see all the photo winners for 2017, go to [www.vernier.com/r1717](http://www.vernier.com/r1717)

## Amusement Park “Round Up”

Chris Murray, of Tualatin High School in Tualatin, Oregon, recently sent us some great data taken with LabQuest and a Low-g Accelerometer on an amusement park ride called Zero Gravity (also known as Round Up). As the ride began, a student held the Accelerometer at chest level, pointed horizontally. When the motion started, two things happened: the axis of rotation tipped down and the angular speed increased.

There are so many more things you could investigate: How fast was the ride rotating at the maximum? How do you explain the shape of the graph? Why did they call the ride Zero Gravity?



Acceleration data with the Accelerometer pointed away from the center of the ride

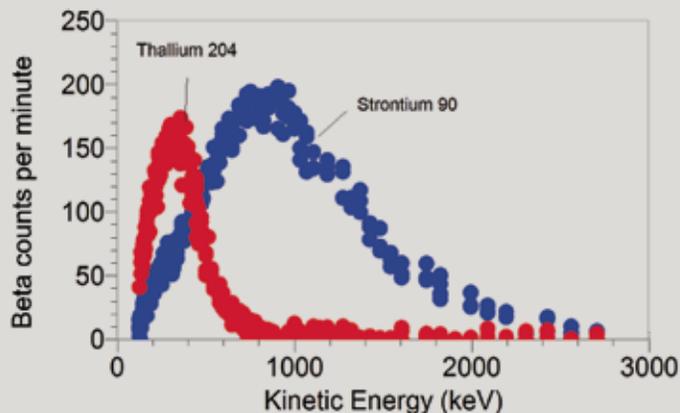
## An Inexpensive Beta Radiation Spectrometer

When studying radioactivity, most students have heard that the consequences include everything from Godzilla to spider senses. But few students know we can safely measure the energy of radiation and study something called nuclear spectroscopy in an ordinary science lab.

A beta radiation spectrometer can be built from a Vernier Radiation Monitor, a couple of strong magnets, and a Rotary Motion Sensor. If you do not have a Rotary Motion Sensor, a protractor can be used in its place to collect data manually.

The source under study sends beta particles into a strong magnetic field. Magnets bend the path of the charged beta particles. The least energetic particles bend the most, emerging with a larger deflection angle, and the most energetic particles bend the least. As a result, the energy of a beta particle can be calculated from the deflection angle. By slowly rotating a radiation source while measuring the radiation at the other side of the magnets, you can find the number of counts per minute at

any given angle. A little physics converts the measured angle to a corresponding energy. The result is a spectrum of beta radiation that can be compared with published spectra. This is one method for identifying radioactive sources.



Beta radiation spectra from Thallium 204 and Strontium 90 were collected with a Vernier Radiation Monitor (VRM-BTD) and a Rotary Motion Sensor (RMV-BTD). The radiation source was slowly rotated by a servo motor over a period of 12 hours. The servo motor was controlled by an Arduino.<sup>™</sup>



A beta radiation spectrometer made from a radiation monitor, a pair of magnets, and a protractor. An energy spectrum can be calculated from radiation counts and angle of deflection.

You can also ask students to find the momentum of the beta particles and then work backwards to calculate speed. If they use Newton's formula for momentum ( $p = mv$ ), they will conclude that the particles moved faster than light! Using Einstein's corrected formula ( $p = \gamma mv$ ), they will find a more accurate estimate of speed, providing a real-world demonstration of special relativity.

For additional information, visit [www.vernier.com/r1718](http://www.vernier.com/r1718)

Plans for these 3D printed parts and those needed for an automated version with angles measured by a Rotary Motion Sensor are available at [www.vernier.com/r1719](http://www.vernier.com/r1719)

We thank Barry Gragg, Sam Russell, and Daniil Frants of The Dwight School in New York for the idea of using a magnet to deflect beta rays into a Vernier Radiation Monitor.

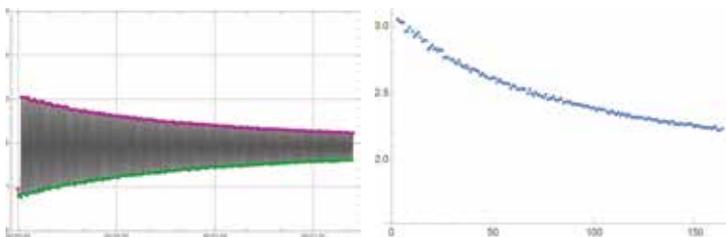
## The Great American Eclipse

Did you see the solar eclipse in August? Vernier employees had the day off to head south so they could be in the path of totality. We collected lots of data during the eclipse in several different locations, as did many other teacher and student groups. If you want to share your eclipse data, graphs, photos, and videos, you can submit them to us, and we will post them at [www.vernier.com/eclipse](http://www.vernier.com/eclipse)

We sponsored an ambitious experiment to replicate the Eddington Experiment with modern, relatively inexpensive equipment. The Eddington Experiment is "the experiment that made Einstein famous." It was first performed in 1919 as a way to prove Einstein's general theory of relativity. Experimenters measure the very tiny deflection of the path of light coming from a star and passing very close to the sun during a total solar eclipse. Groups around the United States took photos during the eclipse using CCD cameras. Since the deflection is so small and there is so much data to analyze, we plan to report our results in a future newsletter.

## Vernier and Mathematica®

You can now use Mathematica to collect data from a Go!Link and different Vernier sensors, thanks to our work with Wolfram Research. In the graphs below, we used the peak-finding feature of Mathematica to do further analysis on data collected with a Dual-Range Force Sensor.

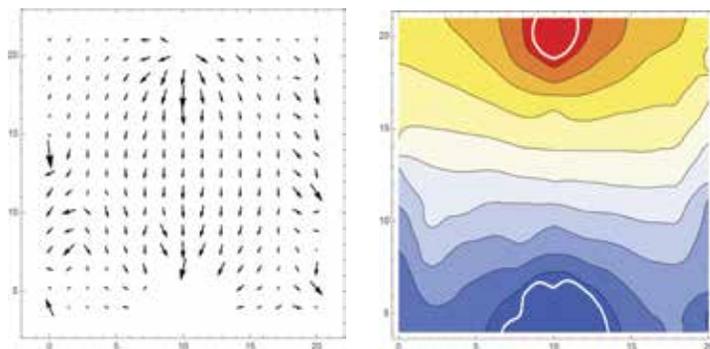


Force measurement as a spring oscillates

Peak force readings oscillates

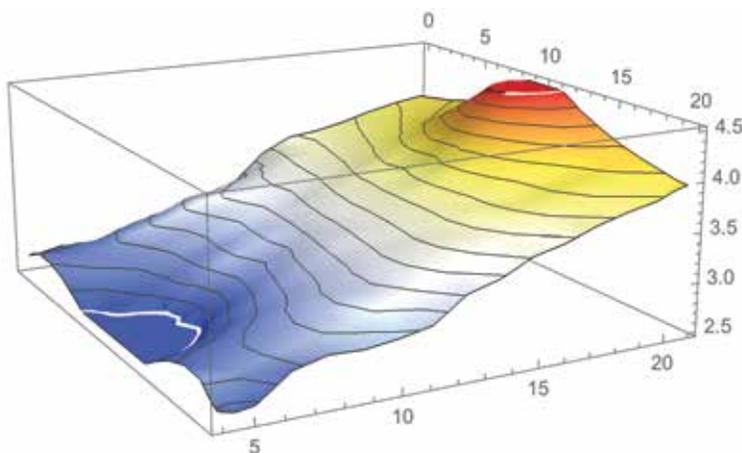
You can also import data taken in a different Vernier data-collection program, such as Logger Pro. The graphics at the right show results from our *Advanced Physics with Vernier – Beyond Mechanics* Experiment 8, “Mapping Electric Potential,” displayed in Mathematica.

We are also working with Wolfram Research with a goal of supporting data collection using LabQuest and Mathematica.



Electric field from a dipole shown as vectors

Potential map from a dipole, 2D



Potential map from a dipole in 3D

## NEW NI LabVIEW™ Installer Includes Bluetooth® Support for LabQuest Stream™

A new LabVIEW installer is now available for LabVIEW versions 2016 and 2017, which makes it possible for you to collect data with LabQuest Stream connected to a computer via Bluetooth. So now, in addition to being able to create LabVIEW programs that take sensor measurements with LabQuest Stream connected via USB, you can create your own custom LabVIEW program and wirelessly stream data to your computer in real time!

The new wireless support can be found in our latest LabQuest and SensorDAQ installer for LabVIEW 2016 and 2017 at [www.vernier.com/r1720](http://www.vernier.com/r1720)

Vernier has a longstanding tradition of providing National Instruments' LabVIEW software support for our hardware, including LabQuest 2, LabQuest Mini, SensorDAQ, and Go! devices.

You may also be interested in our two LabVIEW lab books to help you start programming and doing projects. More information can be found at [www.vernier.com/r1721](http://www.vernier.com/r1721)

## Simplify Arduino™ Programming with the New Vernier Library

One of the best features of Vernier sensors is that they have built-in, auto-ID capability. We have created an Arduino library for our sensors that takes full advantage of this powerful feature. The programming required to automatically detect the sensor, identify sensor parameters (such as units), and apply the correct calibration equation is all handled by the library. As Arduino programmers, you or your students can simply connect a sensor to the Vernier Arduino Interface Shield, add one or two simple function calls to the Arduino sketch (program), and instantly retrieve and plot sensor measurements in the correct sensor units.

In addition to identifying analog sensors, such as a pH Sensor, the library has the ability to read position data from a Motion Detector (MD-BTD), control digital output from a Digital Control Unit (DCU-BTD), control a pulse width modulated (pwm) line from a DCU output, or even control a stepper motor.

We think this new library makes it very simple to introduce Arduino programming to your students. For more information on importing and using the Vernier library, and to view example Arduino sketches, visit [www.vernier.com/arduino](http://www.vernier.com/arduino)

## Vernier Engineering Award

### Win a \$5,500 Award from Vernier

Are you using Vernier sensors to introduce engineering concepts or engineering practices to your students? Maybe you are reading Vernier sensors with Scratch to introduce programming, controlling digital outputs with Logger Pro software, integrating NGSS engineering practices, or using your Vernier sensors with a robotics platform such as LEGO®, VEX®, or Arduino™. Tell us about how you are using Vernier technology in your classroom or lab and you could win one of two \$5,500 awards (one for middle school and one for high school)! Each award consists of \$1,000 in cash, \$3,000 in Vernier technology, and \$1,500 toward expenses to attend either the 2018 NSTA STEM Forum or the 2018 ASEE Annual Conference. For complete rules, examples from past winners, and an online application, go to [www.vernier.com/grants/engineering](http://www.vernier.com/grants/engineering)



## INNOVATIVE USE

### An Inquiry Approach to Understanding the Relationship Between Dissolved Oxygen and Temperature

Roland P. Stout, PhD,  
Univ. of North Carolina at Pembroke

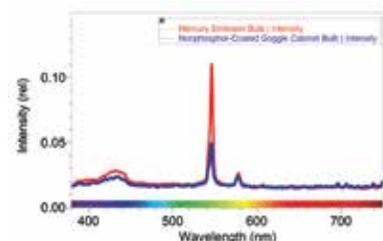


Image credit: Roland P. Stout, Univ. of North Carolina at Pembroke

## INNOVATIVE USE

### Identifying Mercury in Fluorescent Light Bulbs

Doug Balmer, a chemistry teacher from Warwick High School in Lititz, Pennsylvania, designed a lab experiment for his students that investigates the absorption and emission of light using a spectrophotometer. The experiment, entitled “Light Lab: Studying



Identifying mercury as the element found in fluorescent light bulbs

Light and Electrons,” is divided into four parts: understanding how a spectrophotometer works, seeing the connection between wavelength and color, observing atomic line spectra, and looking at the absorption spectra of solutions.

In the past, Balmer’s students used traditional spectroscopes to observe atomic line spectra. However, after acquiring a class set of SpectroVis® Plus Spectrophotometers and Optical Fiber accessories, his students transitioned to using these instead.

One of his objectives when observing the atomic line spectra is to determine the elements found in fluorescent light bulbs. For several years, Balmer’s students had trouble identifying mercury vapor in the bulbs. They could usually narrow it down to mercury and one other element, but the phosphorescent coating on the overhead fluorescent bulbs interfered with the results. As an alternative, he started having the students observe the spectrum of the bulbs inside their goggle cabinet. These bulbs, used to sterilize goggles, are similar to overhead fluorescent bulbs, but lack the fluorescent coating. The small dimension of the Optical Fiber allows it to be fed through the screw holes in the back of the cabinet or the cracks at the door hinges, giving students much better results when comparing the fluorescent light spectrum to the mercury spectrum tube.

For several semesters I have had my freshman chemistry students monitor our campus water feature on a weekly basis using most of the Water Quality Index measurements. The water feature is an artificial pond, roughly two hectares in area and a meter deep. It has two fountains, an amphitheater, and a picturesque bridge that is good for hanging probes into the water. The pond is lined with black rubber, leading to considerable solar heating.

This past year I added a new wrinkle to the experiment, which yielded a powerful teaching moment. I had two students take dissolved oxygen (DO) measurements using the Vernier Optical DO Probe and record both the mg/L and percent saturation values. As I suspected, the percent saturation was typically near 100% (98–100%), but the mg/L values varied throughout the spring. Near the end of the semester, we placed the entire semester’s readings on the board and discussed patterns we saw. Nearly everyone noticed that the percent saturation was always near 100%, while the mg/L values decreased significantly through the semester. None of the students knew what to make of that. I asked them to compare this pattern with other patterns in the measurements. One student finally noticed that the mg/L values decreased as the water temperature increased. I then had them look up gas solubility in their lecture texts, which confirmed the relationship that was observed by the students.

I challenged students to determine the mathematical relationship for solubility vs. temperature using the data we collected. After they kicked around several ideas, the students realized that since all but one of the DO readings were essentially 100%, the mg/L values must represent the saturation limit. Using Logger Pro, they plotted mg/L vs. temperature and obtained the expected solubility curve.

Carefully prompting my students along the way, rather than just telling them the relationships, gave the students ownership in the process. As their confidence grew, they began to see and work out explanations for several other correlations present in the data. Needless to say, it was rewarding to sit back and listen to my students figure it out for themselves.

## Total Equilibrium

Recent visitors to the Portland Art Museum were treated to a viewing of the work *One Ball Total Equilibrium Tank* by the internationally renowned artist Jeff Koons. As visitors admired the piece, they often wondered how the basketball was being suspended in the center of the tank without wires or other visible means of suspension. Was it an optical illusion? A magic trick? No, it was simply the intersection of art and science—a study in equilibrium and buoyant force. With dense, highly saline water in the bottom half of the tank, and less dense distilled water on the top, a basketball of just the right density is held in place by opposing forces.

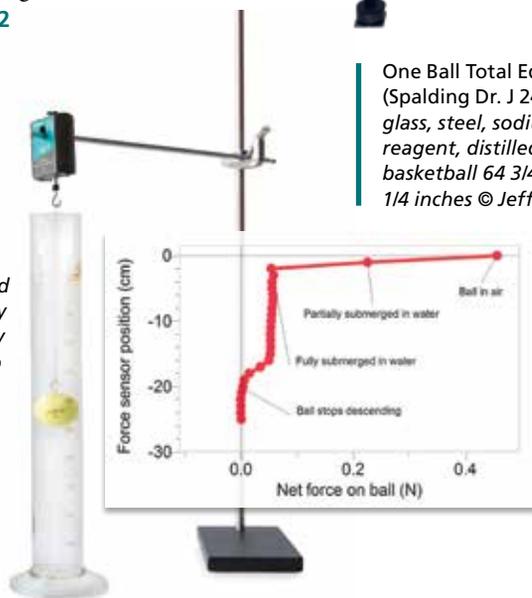
Your students can easily recreate this phenomenon in the classroom. A large graduated cylinder and golf ball work well, but the options are unlimited. To quantify the forces involved, a sensor such as our new Go Direct™ Force and Acceleration Sensor can be used.

When we investigated this phenomenon, we partially filled a graduated cylinder with a saturated solution of sodium chloride in water and then very gently added fresh water. Because of the significant difference in density, these two layers remained stratified with only a few vertical centimeters of mixing. Data were

collected as the golf ball, suspended from the Go Direct Force and Acceleration Sensor, was lowered through the column of water. The data show that as the ball passed through the fresh water, the net force remained fairly constant. As the ball reached the salinity gradient, the net force quickly decreased to 0 N and the ball ultimately stopped its descent. Resting at equilibrium between the two layers of water, the ball was suspended, just like Jeff Koons' iconic basketball.

For details on our investigation, visit [www.vernier.com/r1722](http://www.vernier.com/r1722)

*A Go Direct Force and Acceleration Sensor measures the change in net force on a golf ball as it is lowered through fresh water at the top of the graduated cylinder, enters a salinity gradient, and eventually stops descending due to the buoyant force of the highly saline water in the bottom.*



One Ball Total Equilibrium Tank (Spalding Dr. J 241 Series), 1985 glass, steel, sodium chloride reagent, distilled water, one basketball 64 3/4 x 30 3/4 x 13 1/4 inches © Jeff Koons

We would like to thank the Portland Art Museum ([portlandartmuseum.org](http://portlandartmuseum.org)) for their cooperation and Jeff Koons ([jeffkoons.com](http://jeffkoons.com)) for permission to use the image.

## Potentiometric Titration of Aqueous Iodine

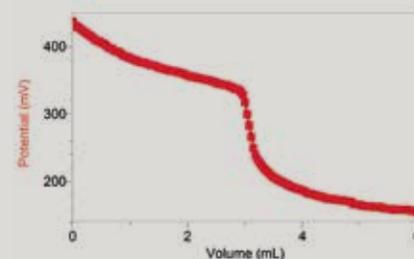
In an iodine redox titration, starch, which turns blue-black in the presence of iodine, is typically used as the indicator. However, this method can be challenging for students because of the low solubility of iodine in water and the pH dependence of the reaction (which proceeds quantitatively in neutral or slightly acidic solutions). Did you know that there are a couple of variations on this experiment that can create a more successful experience for your students?

The first option, written up by Allan Pinhas and published in the *Journal of Chemical Education*, presents the use of povidone iodine, also known as betadine, as the stable source of iodine for the redox titration with thiosulfate. The use

of povidone iodine is appealing because the solution is slightly acidic and the reddish-brown to clear transition works well as a visual indicator, making it easier for students to identify the equivalence point.

As a second variation, we built on Pinhas' innovative work and used an ORP (oxidation-reduction potential) Sensor to analyze the reaction, eliminating the reliance on the visual indicator for identifying the equivalence point. Using an ORP Sensor is analogous to using a pH Sensor for an acid-base titration, but the graph displays potential vs. volume rather than pH vs. volume. In the sample data shown, approximately 5 g of povidone iodine solution was dissolved in 25 mL of water. The titration with a 0.1 M sodium thiosulfate solution was monitored using a Vernier ORP Sensor and a Drop Counter. The equivalence point indicates

the solution is 0.77% iodine, supporting the 1% iodine claim on the label.



Redox titration of iodine in povidone iodine using thiosulfate

Details for preparing the solutions are available through the *Journal of Chemical Education*.<sup>1</sup> For questions about the ORP Sensor or the Drop Counter, email [chemistry@vernier.com](mailto:chemistry@vernier.com)

<sup>1</sup> Allan R. Pinhas, "A Redox Titration for a General-Organic-Biochemistry (GOB) Course Using Povidone Iodine," *J. Chem. Educ.*, 87 (9), 2010, pp. 985–986.

## Mobile Teaching Laboratory Provides Inspiration Using Vernier Products

William H. Roden, senior scientist, and Dr. Amanda L. Jones, Director of the Science Education Department at Seattle Children's hospital, have developed several innovative ways to incorporate Vernier technology into their teaching modules. The modules are designed for grades 4–12 and cover a variety of topics including biotechnology, microscopy, human physiology, and neuroscience. Vernier sensors are used in the modules to teach concepts in respirometry, the physiology of asthma, and how the brain controls body movement. Students enjoy these activities because they are able to collect data and perform analyses like actual healthcare professionals. The modules have been successfully shared with thousands of students across the state of Washington in robust, scalable, one-hour lesson plans that align with Common Core and Next Generation Science Standards (NGSS).



The mobile teaching laboratory

The majority of the modules are taught in a mobile laboratory. Logger Pro 3 software and LabQuest Mini are used with computers, as they are an excellent, portable solution for teaching in confined spaces. In

addition to the user-friendly design of the software, Roden and Jones were very impressed that Logger Pro 3 can be used to create custom files for different experiments. The custom experiment files ensured that students were able to focus on the important aspects of each lesson.

As an example of the lessons that have been developed, the *Vital Signs* module serves as a basic introduction to normal human physiology and emphasizes how monitoring vital signs can be useful in detecting medical problems. Students use the Vernier Spirometer to measure respiratory rates in this module.



The airflow-restricted Spirometer

able to compare the “normal” and “airflow-restricted” data sets in Logger Pro.

The *Sense, Think, Move* module uses the Vernier EKG Sensor and focuses on the role of the brain as the control center of the body. Students measure the electrical activity in their forearm muscles as they perform a series of hand movements: gentle squeezes, hard squeezes, and fast wrist flips. This activity is always a big hit with the students.



Students collecting data in the Sense, Think, Move module

We are very grateful that Roden and Jones shared with us how they use Logger Pro 3, LabQuest Mini, and our Spirometer and EKG Sensors in their mobile science teaching laboratory. For more information about the Science Education Department at Seattle Children's hospital, and to see how they are using Vernier products to inspire the next generation of scientists and healthcare professionals, visit [www.adventurelab.org](http://www.adventurelab.org)

For questions about how to use Vernier sensors and software to teach human physiology, contact [physiology@vernier.com](mailto:physiology@vernier.com)



## New Face in the Biology Department

We are excited to announce that Sara Tallarovic has joined the Vernier team as a Biology Educational Technology Specialist. Sara has over 15 years of teaching experience at the college level. She received her PhD at Oregon State University and was a Professor of Biology at the University of the Incarnate Word, a small liberal arts college in San Antonio, Texas. Sara used Vernier sensors in all of her courses, which included Introductory Biology, Human Physiology, Animal Physiology, and Animal Behavior. As an advocate for science education, Sara was also involved in K–12 outreach activities throughout her career, including STEM summer programs for middle and high school students. She is an avid hockey fan, hiker, home brewer, gardener, musician, artist, and occasional actress. We are excited to welcome Sara to the Vernier team and hope she enjoys everything Oregon has to offer.

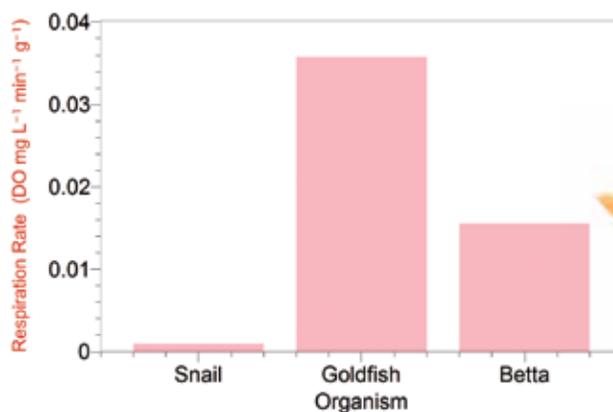
## Study the Evolution of Respiratory Systems with the Vernier Optical DO Probe

Experiments in comparative physiology are an excellent way to teach concepts in evolutionary biology. In the most recent edition of *The Caliper*, we published a well-received, college-level comparative physiology experiment using scorpions and cockroaches ([www.vernier.com/r1723](http://www.vernier.com/r1723)). In response to the many requests we received for a high-school-level activity, the Vernier Biology department put their heads together and came up with an experiment that investigates the comparative physiology of snails and fish using a Vernier Optical DO Probe (ODO-BTA, \$299).

Snails are slow moving creatures that have an open circulatory system. In an open circulatory system, oxygenated and deoxygenated blood are not separated into a system of arteries and veins. Oxygenated blood from the gills flows into the heart and then out into sinuses. From there, it flows to other body tissues and eventually returns to the gills. In contrast, fish have a closed, single-loop circulatory system with arteries and veins. Deoxygenated blood from the tissues flows to the heart where it is then pumped to the gills. The blood is oxygenated by the gills, travels out to the tissues of the body, and then returns to the heart.

Some fish have also developed behavioral and anatomical adaptations for living in aquatic environments with very little oxygen. The Siamese fighting fish (*Betta splendens*), or Betta as it is often called, has small gills for its size. But it also has a special organ that allows it to absorb oxygen from the air with its mouth. This is an adaptation for living in rice paddies and shallow pools in tropical areas.

In this activity, students measure the respiration rate of an aquatic snail, a goldfish (*Carassius auratus*), and a Betta using a small respiration chamber and an Optical DO Probe. Students collect data over a relatively short time interval (20 minutes), ensuring that the activity can be done in a typical high school class period. After collecting data, students calculate and compare the respiration rate of each organism.



A comparison of the respiration rates of fish and snails

Organisms with a closed circulatory system should have higher respiration rates than organisms with an open circulatory system. One would also expect the Betta to have a lower respiration rate than the goldfish, since it has evolved to live in aquatic environments with little oxygen. As can be seen in the graph, the snail has the lowest respiration rate, the goldfish has the highest respiration rate, and the Betta has an intermediate respiration rate. For questions about this activity, you can contact [biology@vernier.com](mailto:biology@vernier.com)

You can find the student and teacher instructions for this activity at [www.vernier.com/r1724](http://www.vernier.com/r1724)



## Vernier Sponsors National KidWind Challenge

Over 400 students, coaches, and parents participated in this year's National KidWind Challenge at the American Wind Energy Association WINDPOWER conference. Each year, teams from all over the United States compete to design the most efficient kid-built wind turbines and test their knowledge of wind energy. In addition to regional challenges, the nonprofit KidWind Project also sponsors monthly online mini-challenges for educators. See results, meet the winners, and watch team videos at [www.vernier.com/xf1](http://www.vernier.com/xf1)



Photo from this year's National KidWind Challenge provided by KidWind Project

## Vernier Sponsors NABT Ecology/Environmental Science Teaching Award

Each year, Vernier sponsors the NABT Ecology/Environmental Science Teaching Award. The award includes \$500 toward travel to the NABT Professional Development Conference and \$1,000 in Vernier equipment. Applications for the 2018 award will be available on the NABT website soon after the November conference, and the deadline for submission is March 15, 2018. Details are available at [www.vernier.com/grants](http://www.vernier.com/grants)

# Vernier in the Journals

## Playing with the Bulb Lamp: RTL Measurements and Modelling

G Torzo (Padova, Italy), M D'Anna (Locarno, Switzerland), and B Pecori (Bologna, Italy), *Physics Education*, 51 (5), September 2016.

This article describes many aspects of the operation of an incandescent lamp, including how light level, current, and potential vary. With the 50 or 60 Hz AC applied to the filament, a lot of interesting things are going on.

Suggested Products: Go Direct Voltage, Go Direct Light and Color

## Using Flatbed Scanners in the Undergraduate Optics Laboratory—An Example of Frugal Science

Thomas Koopman and Venkatesh Gopal (Elmhurst College, Illinois), *American Journal of Physics*, 85 (5), May 2017.

This article describes using low-cost commercial flatbed scanners to scan and study interference and diffraction patterns. The authors used the Vernier Diffraction Apparatus to produce the diffraction patterns.

Featured Products: Diffraction Apparatus

## A Glowing Recommendation: A Project-Based Cooperative Laboratory Activity to Promote Use of the Scientific and Engineering Practices

Justin H. Carmel, Joseph S. Ward, and Melanie M. Cooper, *J. Chem. Educ.*, 94 (5), 2017, pp. 626–631.

This article discusses how to incorporate NGSS skills and processes into studies involving glow sticks. Students used the Vernier SpectroVis® Plus Spectrophotometer and Logger Pro software to collect fluorescence spectra from glow stick reactions. This was done by placing the software in intensity mode and then monitoring the spectrum produced by the reaction in the cuvette. The authors proposed experiments to study the kinetics of the reaction involving catalysts, temperature, acids, and bases. One goal was to extend the period of emission from the glow sticks. In another experiment, students attempted to mix the dyes from the glow sticks to produce more intense emissions. Solvent-resistant plastic cuvettes were used to avoid damage to the SpectroVis Plus.

Featured Products: SpectroVis Plus and Logger Pro software

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For more articles, visit [www.vernier.com/r1725](http://www.vernier.com/r1725)

## Software Updates

We regularly release software updates to support new sensors, add new features, and 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 recently? Updates are free, and, to coincide with the release of Go Direct™ sensors, updates are available for nearly all our software.

For updates to Logger Pro for macOS® and Windows®, as well as for LabQuest App, visit [www.vernier.com/downloads](http://www.vernier.com/downloads)

Graphical Analysis 4 on macOS and Windows detects the availability of an update and notifies you with a red dot on the overflow menu in the app.

Graphical Analysis 4 on Chromebook™, iOS®, and Android™ also updates automatically. You can ensure you have the current version by deleting the app and reinstalling it from the appropriate app store.

## Applications Open for Annual Vernier/NSTA Technology Awards

Vernier Software & Technology and the National Science Teachers Association (NSTA) are now accepting applications for the annual Vernier/NSTA Technology Awards. The 2018 awards program will recognize up to seven educators—one elementary teacher, two middle school teachers, three high school teachers, and one college-level educator—who promote the innovative use of data-collection technology. Prizes include \$1,000 in cash, \$3,000 in Vernier products, and up to \$1,500 toward expenses to attend the 2018 NSTA National Conference in Atlanta, Georgia. Award recipients are chosen based on their application, which is judged by a panel of NSTA-appointed experts. All applications must be submitted by December 15, 2017. For more information about the award and to read about this year's winners, visit [www.vernier.com/grants](http://www.vernier.com/grants)

# FREE Hands-on, Data-Collection Workshops

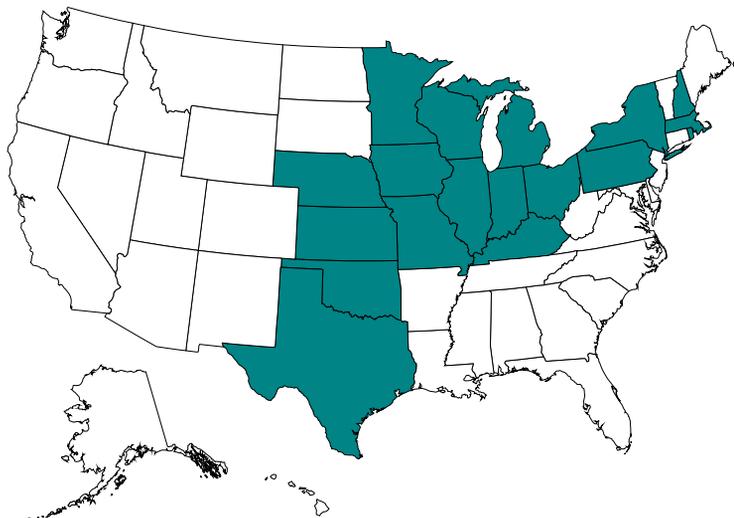
Calling all science educators! Join us for a four-hour exploration of the latest and greatest in Vernier probeware and data-collection technology. You will conduct hands-on experiments using a variety of interfaces and sensors, including our new Go Direct sensors with options for wireless and USB connectivity.

## Perfect for science educators interested in

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- Learning from the experts

## Attendees receive

- Four hours of free training
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KY	Lexington 9/23 • Louisville 9/21
MA	Boston 10/17
MI	Detroit 10/14 • Grand Rapids 10/12
MN	Minneapolis 10/2
MO	Kansas City 9/27 • St. Louis 9/19
NE	Omaha 9/28
NH	Nashua 10/18
NY	Albany 10/14
OH	Cincinnati 9/25 • Cleveland 10/16
OK	Oklahoma City 9/23 • Tulsa 9/25
PA	Pittsburgh 10/17
RI	Providence 10/16
TX	Austin 9/18 • Dallas 9/20 • Ft. Worth 9/19 • Houston 9/13 • Houston 9/14 • San Antonio 9/16
WI	Madison 10/3 • Milwaukee 10/2

## Science Humor



**An infinite number of mathematicians go into a bar. The first one orders a pint of beer. The second asks for half a pint. The third one says, "A quarter of a pint for me!" The fourth one asks for an eighth of beer, and so on. After a while, the bartender gets bored, sets two beers on the bar, and says, "Sort this out amongst yourselves—you know your limits."**

**A couple of biologists had twins. They named one Jessica and the other Control.**

**A fellow accidentally ingested some alpha-L-glucose and discovered that it had no ill effect. Apparently, he was ambidextrose.**

## 30 Years Ago in This Newsletter

Vernier Software & Technology started out as an Apple II-exclusive, physics-only company. Thirty years ago, we began branching out a bit with the introduction of our first chemistry sensor, the pH Sensor. Later that same year, we also introduced our first products for the "new" IBM PC and MS-DOS.



Vernier Software & Technology  
 13979 SW Millikan Way  
 Beaverton, OR 97005-2886  
 888-VERNIER (888-837-6437)  
 fax 503-277-2440  
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