Vernier

THE Caliper

SPRING 2019

A Publication for Users of Vernier Products

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Building a Better Mousetrap—A New Vernier Photogate

We are excited to announce a new sensor for physics—Go Direct® Photogate. With our first-ever wireless photogate, you get better-than-stopwatch timing accuracy of a cart traveling eight or more meters without having to run wires between the gates.

Go Direct Photogate is actually three photogates in one. The interior arms of the photogate include two photodiodes. This double-gate design measures velocity more accurately and makes it possible to measure speed without needing to know the object's dimensions. The direction of motion is indicated by positive or negative velocities determined by the order in which the internal gates are blocked. The third photogate is a laser gate that you can use with a laser pointer (not included) to make a single gate of any width.

You can use Go Direct Photogate with all of our existing photogate accessories including the Laser, Picket Fence, Cart Picket Fence, Ultra Pulley, and Bar Tape. You can mount Go Direct Photogate on our dynamics track using the existing photogate brackets without any additional parts or adapters.

For more information about this and other Go Direct sensors, visit www.vernier.com/physics

ABOVE

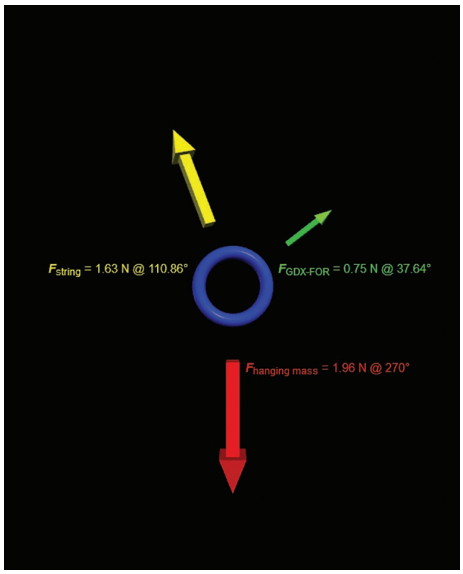
Students measure the acceleration due to gravity using Go Direct Photogate.

Live Free Body Diagram Using Python

During most projectile motion lessons, students inevitably ask, "What about air resistance?" The typical, albeit unsatisfying, response is that a lot of math is required. It's a laborious process, but it's a great task to hand off to a computer!

Numerous coding resources are now available that make computational solutions to physics investigations much easier. VPython is a Python® package that simplifies visualizations of vectors, objects, and trajectories. When students combine VPython with our Go Direct Python library, they can bring real-world, real-time data into computational physics activities.

We used VPython and the Go Direct Python library to create a live free body diagram of a ring with three forces acting on it: a hanging mass and two supporting strings. One string is fixed to a ring stand and the other is attached to Go Direct Force and Acceleration. VPython collects force and acceleration data from the sensor and uses that data to draw a force vector that points in the same direction as the sensor. The free body diagram continuously updates as students move the sensor; the force vectors change length and direction to match the arrangement in real life.



Free body diagram for the ring showing the forces on the ring from the hanging mass (red), Go Direct Force and Acceleration (green), and support string (yellow)

Learn more at www.vernier.com/r191

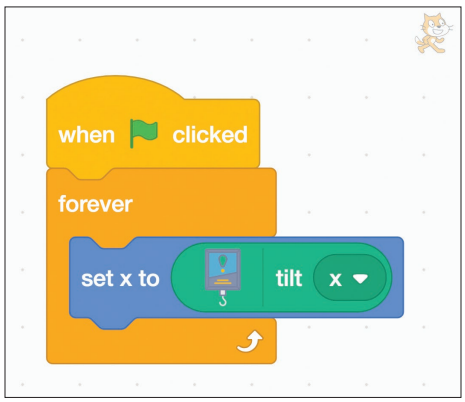
One Device for Teaching Science and Coding with Scratch

Do you teach force and motion? Equipped with a load cell to measure force and both an accelerometer and gyroscope to measure motion, our Go Direct® Force and Acceleration is perfect for hands-on science activities. Drag a sneaker across the floor to study friction, or tie Go Direct Force and Acceleration to a string and swing it around your head to investigate circular motion. Incorporate the sensor in your LEGO® machines and measure the mechanical advantage of levers and ramps.

If you use Scratch to teach coding, you can also easily use Go Direct Force and Acceleration to teach basic programming skills and computational thinking. When students add the Go Direct Force and Acceleration extension in Scratch 3 (the most recent version of Scratch), they have access to several new blocks/commands that can be used to control Sprites. For instance, students can use the Go Direct Force and Acceleration Sensor "tilt" reporter block as the x-coordinate of a Sprite's position. As students tilt the sensor back and forth, the Sprite moves side to side. Students can also write code to use the sensor as a trigger to start and stop action or even as a virtual slingshot.

Scratch 3 also supports other hardware, such as the BBC micro:bit™ microcontroller and LEGO® robots. Adding multiple extensions to your Scratch project means that you can use Go Direct Force and Acceleration to control your LEGO® MINDSTORMS® EV3 robot or use a micro:bit to display force or acceleration readings.

Science investigations and coding activities are great complements to each other. Science investigations using Go Direct Force and Acceleration help students build understanding of forces, motion, and Newton's laws. Coding activities with the same sensor provide additional context and motivation and give students an outlet for creative expression.



Tilt the Force and Acceleration sensor back and forth and your sprite moves side to side.

Learn more about the Go Direct Force and Acceleration extension for Scratch 3 and see sample projects at scratch.mit.edu/vernier

INNOVATIVE USE

Test Your Balance with *Human Physiology Experiments*

Our new *Human Physiology Experiments* lab book contains a complete set of laboratory instructions for our Go Direct human physiology sensors. This book also includes several new and exciting activities, such as the "Balance" experiment.

Balance is a complex task that involves input from multiple sensory sources. Visual input, proprioceptors from the limbs and joints, and input from the inner ears are all involved in balance. In "Balance," students use the accelerometers in Go Direct Force and Acceleration to detect movement as a subject balances on two legs and then on one leg, with eyes open and then closed.

Students intuitively understand that it is much easier to balance with their eyes open, but now they can measure the magnitude of movement for each condition using acceleration data. Less stability results in larger and more frequent movements, which produce greater accelerations. As illustrated by the graph on the right, there is much more movement by the subject when the eyes are closed than when the eyes are open.

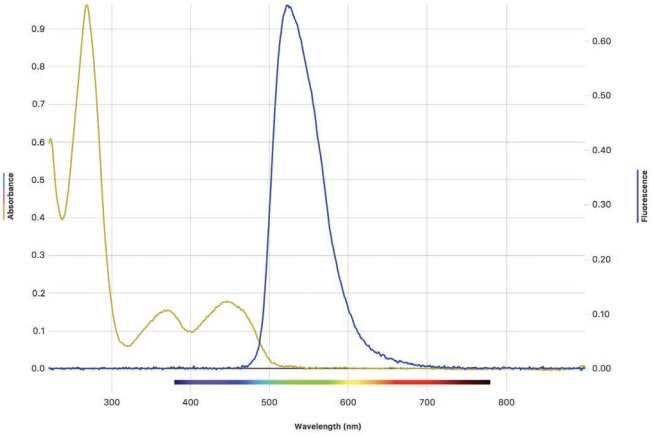
This unique and simple activity is an excellent way to explore how different sensory systems are involved in balance.

Download the instructions for doing the "Balance" experiment with Go Direct sensors at www.vernier.com/r192

Explore Vitamins with New Features of Spectral Analysis

Vitamin B2, also known as riboflavin, was first isolated in 1933. It is an essential nutrient for humans as the precursor of the coenzymes flavin mononucleotide (FMN) and flavin adenine dinucleotide (FAD). FAD plays a key role in several important enzymatic reactions in metabolism, including the Krebs cycle. Riboflavin also happens to be a relatively stable, strongly fluorescing compound that makes it ideal for investigations using a fluorescence spectrophotometer, such as the Go Direct® SpectroVis® Plus or the Vernier Fluorescence/ UV-VIS Spectrophotometer.

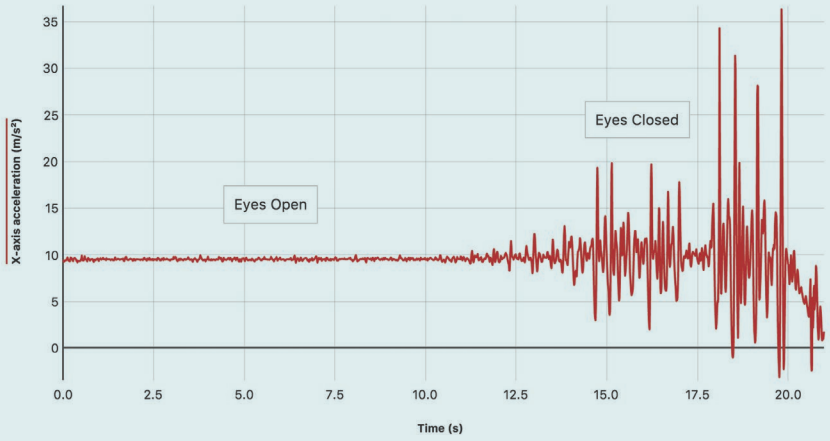
Our chemistry team recently posted a free experiment to our website, "Absorbance and Fluorescence Characterization of Vitamin B2." In the experiment, students explore the properties of riboflavin using a spectrometer and our free, recently updated Vernier Spectral Analysis® Spectral Analysis v4.8, released in February 2019, now includes fluorescence support. You still get the user-friendly interface that walks students through the data-collection process to easily set up a full spectrum experiment, Beer's law experiment, kinetics experiment, or emissions; but now you will have these options for fluorescence data as well. In addition, we've added an Advanced Full Spectrum mode that allows you to compare multiple experiment types (absorbance, percent transmittance, fluorescence, and emissions) within the same file. Examples for using this option include inquiry-based analysis of an unknown sample, investigating the relationship between absorbance and % transmittance, and investigating the Stokes shift of a sample using absorbance and fluorescence spectra.



Absorbance and fluorescence spectra of vitamin B2

For complete details on Spectral Analysis, see our new user manual at www.vernier.com/sa4-manual

Download the entire experiment at www.vernier.com/r193.



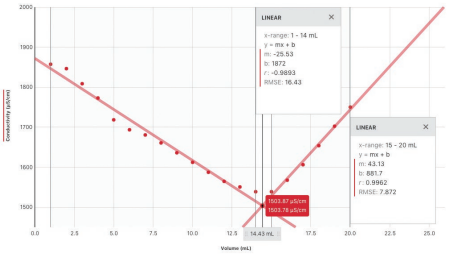
The built-in accelerometer in Go Direct Force and Acceleration can be used to detect movements as a subject balances on one leg with their eyes open and then with their eyes closed.

Conductometric Titration: An Alternative to Gravimetric Analysis

Gravimetric analysis is a classic technique for determining the mass of an analyte through precipitation. Because of the complex nature of gravimetric analysis, it can be a challenging experiment. In an article published in the *Journal of Chemical Education*, authors Jennifer Garcia and Linda Shultz compare a conductometric titration to conventional gravimetric analysis and conclude that the titration is less time consuming, more predictable, and less hazardous.[1] The use of Vernier conductivity probes and Graphical Analysis 4 to perform and analyze a conductometric titration helps students develop skills and knowledge expected by the Next Generation Science Standards (NGSS) and state standards.

In "Determination of Sulfate by Conductometric Titration: An Undergraduate Laboratory Experiment," Garcia and Schultz describe how students titrate a solution of K_2SO_4 with $BaCl_2$, monitor the changes in conductivity, and manually graph the data. As the reaction proceeds, the resulting product $BaSO_4$ precipitates out of solution, lowering the conductivity. The precipitation is complete at the equivalence point and by continuing to add $BaCl_2$, the conductivity increases.

With a few small changes to the procedure developed by Garcia and Schultz, your students can complete a conductometric titration using Go Direct Conductivity.



Students can determine the equivalence point of a conductometric titration using Graphical Analysis™ 4.

Learn more at www.vernier.com/r194

1 Jennifer Garcia and Linda Schultz; *Journal of Chemical Education*, 2016, 93 (5), pp 910–14.

Vernier in the Science Journals

Physics

Improved Gay-Lussac Experiment Considering Added Volumes

Nelson Kilmer and Joel D. Krehbiel (Hesston College, Kansas);
The Physics Teacher, 57, January, 2019, pp 21–25.

Pressure sensors are often used to estimate absolute zero. This article explains how to improve the result if you account for the air that is inside both the tubing and the sensor.

Using a Modified Boyle's Law Experiment to Estimate the Density of Salts

Joel D. Krehbiel, Kenton N. Schroeder, Harune Suzuki, and Nelson Kilmer (Hesston College, Kansas);
The Physics Teacher, 57, January, 2019, pp 58–59.

This article explains how to use Boyle's law to easily measure volume using Vernier pressure sensors.

Adding Math to Science

Drew Nelson (Logan HS, Logan, UT) and Todd Campbell (University of Connecticut, Connecticut);
The Science Teacher, October, 2018, pp 26–32.

This article describes a multiple-day unit on friction in which the students take force data, make graphs, and use models that demonstrate several NGSS standards.

A Mystery in Motion

Amy Choffin and Laura Johnson (Northern Hills Elementary School, Oklahoma);
Science and Children, July, 2018, page 56.

This article explains how grade school teachers introduce their students to sensors, graphing, and motion while using our Go! Motion® sensor.

Chemistry

A Second Look at the Kinetics of the Iron–Oxygen Reaction: Determination of the Total Order Using a Greener Approach

A. M. R. P. Bopegedera (The Evergreen State College, Washington);
J. Chem. Educ., 95, 2018, pp 1897–1899.

The author demonstrates how to use Vernier Oxygen Gas Sensors and Logger *Pro* 3 software to monitor the change in oxygen level as the iron in commercial hand warmers react with the air above them.

Investigating the Clough, Lutz, and Jirgensons Rule for the pH Dependence of Optical Rotation of Amino Acids

Scott Simpson and Alexandra M. Izydorczak (St. Bonaventure University, New York);
J. Chem. Educ., 95, 2018, pp 1872–1874.

Students use a Vernier Chemical Polarimeter and Logger *Pro* 3 software to determine if lowering the pH on L configuration amino acids causes the molar optical rotation to become more positive.

Buffers in Context: Baby Wipes as a Buffer System

Jon-Marc G. Rodriguez, Sarah Hensiek, Jeanne R. Meyer, Cynthia J. Harwood, and Marcy H. Towns (Purdue University, Indiana);
J. Chem. Educ., 95, 2018, pp 1816–1820.

Students use baby wipes and deionized water to create and test buffer solutions. Vernier pH Sensors and LabQuest® 2 interfaces help students study the buffer solutions.

Demonstration Extensions Based on Color-Changing Goldenrod Paper

Donald K. Schorr and Dean J. Campbell (Bradley University, Illinois)
J. Chem. Educ., [Online early access], DOI: 10.1021/acs.jchemed.8b00341, Published Online: Dec 5, 2018, https://pubs.acs.org/doi/10.1021/acs.jchemed.8b00341 (accessed Feb 8, 2019).

The authors used a Vernier UV-VIS Spectrophotometer to examine ultraviolet and visible absorbance spectra from extracts of goldenrod paper.

See more articles for chemistry at www.vernier.com/r195

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 help things run smoothly in your classroom or lab. Have you updated your Vernier applications in the last few months? Updates are free, and with the release of new Go Direct® sensors, we've updated nearly all our software.

For updates to Logger *Pro*® 3 for macOS® and Windows®, as well as for LabQuest App, visit 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.

To update Chrome™, iOS, and Android™ applications, including Graphical Analysis 4 app, search the appropriate app store. Updates will eventually be applied automatically, but you can be sure of the current version by deleting and reinstalling the app.

2019 Winners of the Vernier $5,500 Engineering Contest

Vernier Software & Technology sponsors a contest for educators who innovatively use Vernier sensors to introduce engineering concepts or engineering practices to their students. The winner receives $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 2019 Winner!

Eric Tom, a teacher and assistant principal at Don Bosco Technical Institute in Rosemead, California, teaches a course that investigates green and sustainable technologies using Vernier probeware. The course is heavily project-based and is aligned to the Next Generation Science Standards (NGSS). Students design, build, and test wind turbines, simple off-grid solar power systems, and energy-efficient lighting systems.

Honorable Mention

Heather Overkamp, a science, technology, engineering, and math teacher at I.C. Norcom High School in Portsmouth, Virginia, has her students research insolation and identify the plants that can be used as a food source at their latitude. Students then build and test their own greenhouse designs that incorporate Vernier temperature probes. The Experimental Design course that Heather teaches also provides students with an opportunity for inquiry investigations in which students design solutions for a local environmental problem.

To see details about the contest and videos of the winning entries, visit
www.vernier.com/r196

Vernier Supports STREAM Girls

STREAM Girls, a new outdoor STEM program for girls, is a partnership between Trout Unlimited and the Girl Scouts of America. Using water quality testing equipment donated by Vernier Software & Technology, this watershed experience combines STEM education, recreation, and arts to explore a local stream. Every person is a citizen of her watershed, and by visiting a local stream and having the opportunity to observe it as scientists, anglers, and artists, girls get the complete picture of what their stream could mean to them. Beyond science, Scouts were introduced to fly fishing, camping, conservation, and outdoor ecology. Trout Unlimited and the Girl Scouts of America hope to continue to inspire new leaders that will steward and conserve our country's precious natural resources.

Photos courtesy of Trout Unlimited

35 Years Ago in this Newsletter

In our first newsletter in 1984, we announced our new Frequency Meter program for Apple II and our first (and only) program for Commodore® 64, Precision Timer.

2018 Ecology/Environmental Science Teaching Award Winner Announced

Lacey Hoosier of Buckeye High School in Rapides Parish, Louisiana, was the 2018 recipient of the National Association of Biology Teachers' NABT Ecology/ Environmental Science Teaching Award, which is sponsored by Vernier.

Lacey's students are active learners who participate in solving engineering problems, educate the community about vital environmental concepts, and volunteer their time to rehabilitate animals while learning about each animal's characteristics and habitat. In addition to teaching, Lacey sponsors and coaches six extracurricular clubs/teams, serves as a Wildlife Rescuer and Rehabilitationist, and advocates for Environmental Science Community Education. Her passion for animals translates to her classroom as many animals surround her students as they learn to become knowledgeable and responsible proponents for the environment.

"Teaching is one of the most rewarding professions in the world," she explains. "We have the unique ability to shape a mind and unlock passions otherwise unknown or unexplored. Our job is to prepare students from all walks of life for a variety of future professions. It is a privilege to be able to influence the next generation by igniting a passion in them for learning about the world around them."

For more information about this award, visit
www.vernier.com/grants/nabt

2019 Vernier/NSTA Technology Award Winners

The annual Vernier/NSTA Technology Awards recognize seven educators—one elementary teacher, two middle school teachers, three high school teachers, and one college-level educator—for their innovative use of data-collection technology in the science classroom. Chosen by a panel of NSTA-appointed experts, winners receive $1,000 in cash, $3,000 in Vernier products, and up to $1,500 toward expenses to attend the annual NSTA National Conference.

For more information and to apply for the 2020 awards program, visit www.vernier.com/grants/nsta

ELEMENTARY SCHOOL

Covey Denton

Greenfield School

Wilson, NC

Covey Denton engages students to form real-world connections by using Vernier sensors to study the arctic biome and the animals that live in these cold climates. Students use Vernier temperature probes to study the thermal insulation qualities of feathers, air, and blubber to discover the unique adaptations that allow arctic animals to survive.

MIDDLE SCHOOL

Rachel Arbor

Altona Middle School

Longmont, CO

First year teacher Rachel Arbor uses data-collection technologies to encourage students to make connections among interdisciplinary subjects such as science, math, and music. Through hands-on collaborative work, students study how energy and waves move through our world. Students are able to directly observe scientific phenomena such as albedo, amplitude, frequency, and velocity.

Christopher Sindt

Washington Middle School

Dubuque, IA

As part of a STEAM-based project, Christopher Sindt challenged his students to plan, create, design, implement, and market a model roller coaster track. Students used photogates to track the velocity of a marble through the track and validate their claims that their roller coasters were safe for patrons.

COLLEGE

Seth Barrett

Muskingum University

New Concord, OH

Assistant Professor of Chemistry Seth Barrett has students study the chemical kinetics and mechanism of the oxidation of iodide by iron (III) ions using Vernier instrumentation and data-collection software in his upper-level chemistry course. Based on proposed elementary steps of the reaction, students determine the rate expression and use the initial rates method to determine which of the steps in the proposed mechanism is rate-determining.

HIGH SCHOOL

Anne Marie Lavelle

St. Edward High School

Lakewood, OH

Ann Marie Lavelle believes it is important for students to understand the environmental impact of pollution on freshwater ecosystems. Students used Vernier technologies to conduct scientific investigations on water quality samples to study the impact of agricultural runoff, pollutions, algae blooms, destruction of habitat, and beach fouling on Lake Erie.

Jocelyn Virtudes

Gaithersburg High School

Gaithersburg, MD

In a co-taught chemistry class, special education/science teacher Jocelyn Virtudes encouraged students to explore how the identity and concentration of Hofmeister anions impact the behavior of macromolecules such as egg whites. Students used Vernier temperature probes to record temperature data during clear-to-cloudy transitions. The scattering of light as salt concentration increases was also studied using a turbidity sensor.

Patrick Wells

Holy Spirit High School

Conception Bay South, NL Canada

Patrick Wells believes sensation and perception are important for the study of science and uses Vernier data-collection devices to support student inquiry. His student-centered learning model encourages students to observe, think, challenge prior misconceptions, and resolve questions with group members and teachers, leading to the formation of durable memories.

Active Learning in Introductory Physics Courses

July 15–17, 2019

David Sokoloff and Ron Thornton will once again be conducting a multiday workshop for college, university, and high school physics instructors at our office in Beaverton, Oregon, this summer.

For more information and to register, visit www.vernier.com/r197

Science Humor

Two satellite antennas got married. The ceremony was only so-so, but the reception was fantastic.

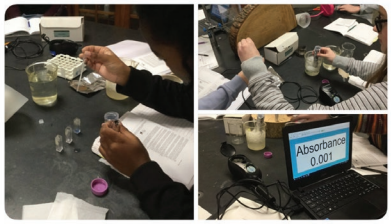
I thought about cutting my sodium intake, but then I was like, "Na."

Parallel lines have so much in common, it's a shame they'll never meet.

Follow @VernierST on Twitter

Jay L. Meyers
@jdkatmeyers

@CHS_Indians biology students observing the light dependent reactions and measuring rates of photosynthesis using @VernierST colorimeters.



frasier_engineering
@frasierpofe

Passing around the @VernierST dynamometer to see who has strongest grip #frasierfirst @SmartLab_tweets

PROFESSIONAL DEVELOPMENT WORKSHOPS

HANDS-ON SUMMER PROFESSIONAL DEVELOPMENT INSTITUTES

Most schools may close for the summer, but the learning never stops at Vernier. Whether you are currently using Vernier technology in your classroom or just exploring the use of probeware, join us for a full-day training opportunity led by a former science educator with years of classroom experience. Connect with peers to share ideas and leave with classroom-ready experiments that will have a positive impact on your students all year.

The cost of the institute is $99, which includes an electronic lab book of your choice. For registration options, including discounted workshop hardware packages, visit www.vernier.com/summer-institutes

SUMMER INSTITUTES

Location		Date
CA	Los Angeles	6/18
	San Diego	6/20
CO	Denver	6/11
IL	Chicago	7/22
IN	Indianapolis	7/24
MA	Boston	7/19
NY	Long Island	7/17
OH	Columbus	7/26
PA	Philadelphia	7/15
UT	Salt Lake City	6/14

FOR MORE INFORMATION AND TO REGISTER, VISIT WWW.VERNIER.COM/SUMMER-INSTITUTES

STEM PROFESSIONAL DEVELOPMENT INSTITUTE

July 11–12, 2019

Held in Beaverton, Oregon, at the Vernier Office

Are you looking for easy and reliable ways to incorporate data-collection technology into your classroom? Join us for a 2-day STEM Professional Development Institute at our headquarters in Beaverton, Oregon. Multiple hands-on sessions covering biology, chemistry, coding/robotics, environmental science, and physics will be offered to customize your experience to your teaching needs.

Examples of topics that will be covered include the following:

PHYSICS

- Kinematics and Newton's Laws
- Momentum and Energy Investigations
- Electricity and Electric Circuits
- Light and Modern Physics

CHEMISTRY

- Acid/Base Titration
- Beer's Law
- Determining Mole Ratio
- Conductivity Titration
- Food Chemistry Experiments
- Forensic Chemistry Experiments

BIOLOGY

- Physiology
- Cell Respiration
- Photosynthesis
- Transpiration
- Enzymes

ENVIRONMENTAL SCIENCE

- Renewable Energy and STEM
- Weather
- Water Quality
- STEM in the Environment

ROBOTICS/CODING

- Scratch Programming
- Coding with mBot™
- LEGO® EV3
- Arduino®
- Python®/Javascript™

The $199 registration fee includes lunch on both days and an electronic lab book of your choice.

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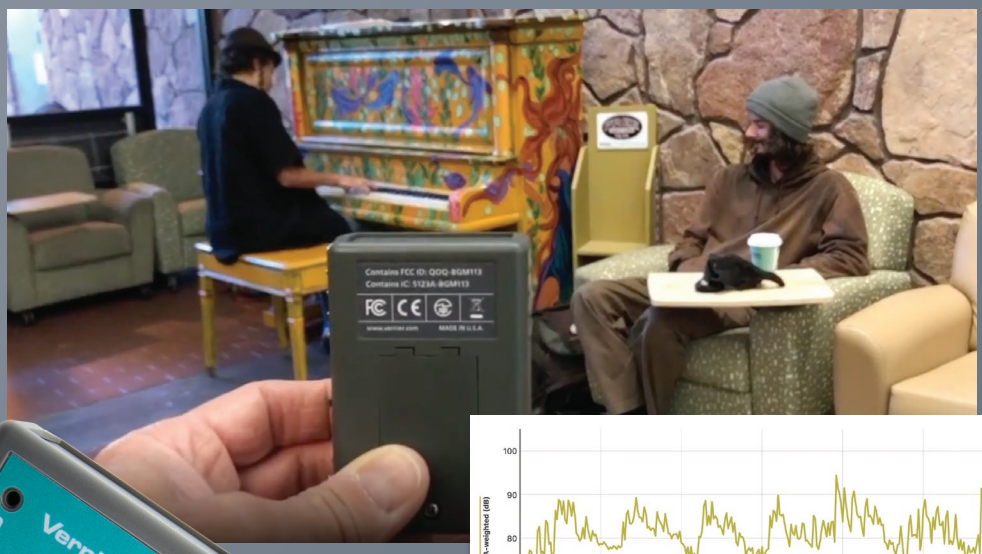
HOW LOUD IS YOUR CAMPUS?

Martin Horejsi, from *NSTA Recommends*, has collected data with Go Direct® Sound just about everywhere on campus. In his recent review, Martin concludes that

> **"The Vernier Go Direct Sound Sensor is a welcome addition to the family of Bluetooth sensors giving our students a tremendous visual inspection into the world of sound. And it really does put a face on those eardrum-generated electrical pulses bouncing around inside their brains."**

Watch the video of the sound sources he captured around his campus at www.vernier.com/r198



SHARE YOUR EXPERIMENTS WITH US

How are you using Vernier technology in your classroom or laboratory? Share a video with us at innovativeuses@vernier.com or tag us on social media (@VernierST).