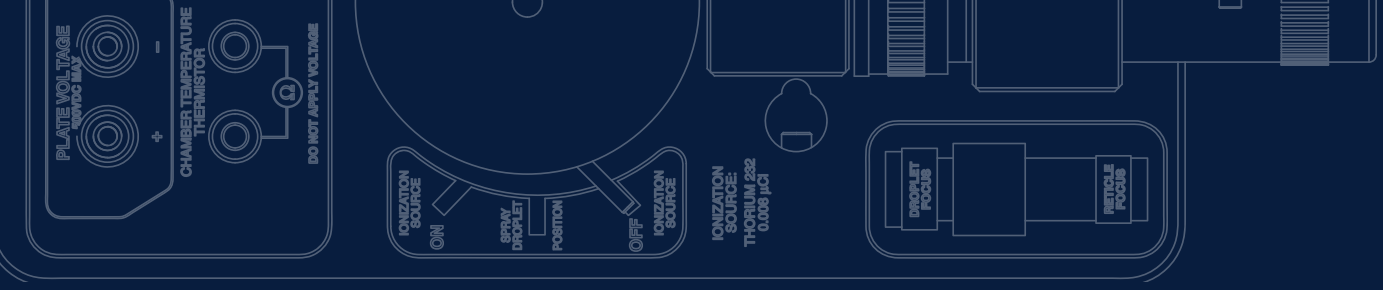
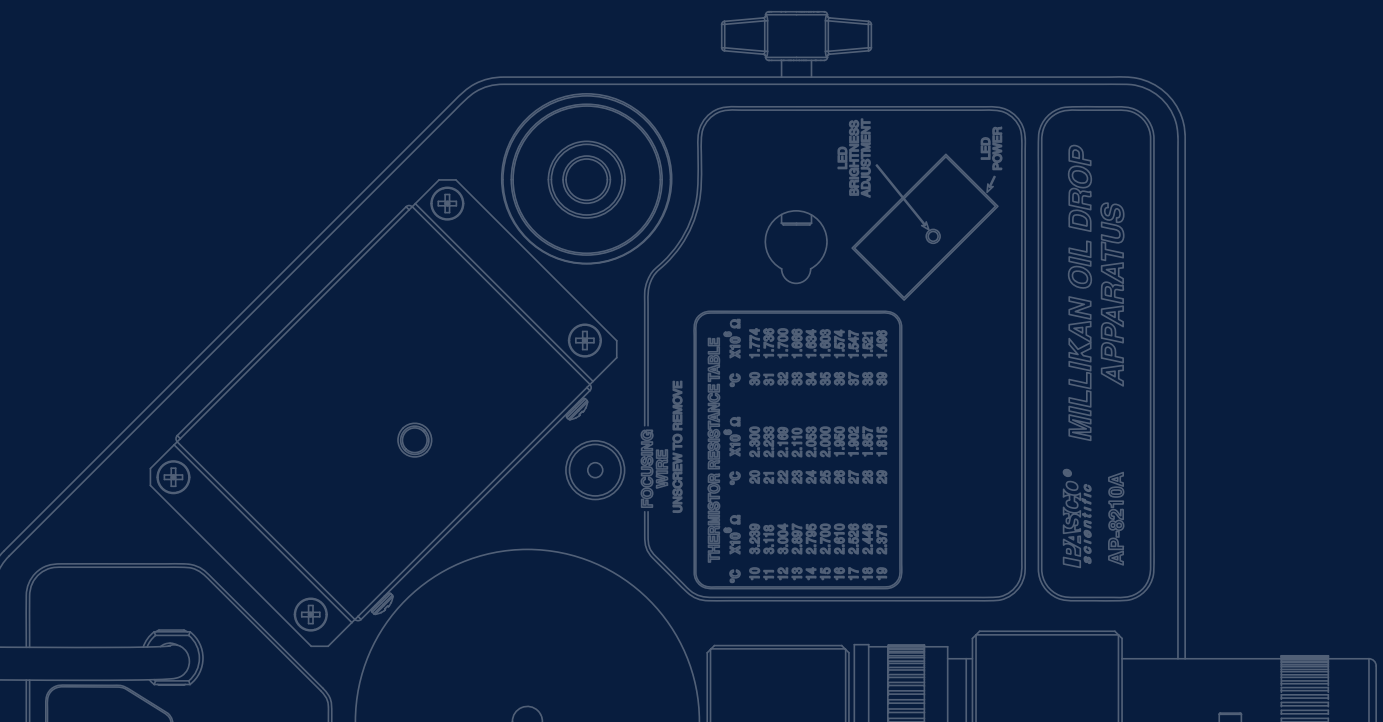


PASCO
scientific
signature series



The PASCO Story

At PASCO, our mission is to provide educators with innovative ways to teach and learn science, so hands-on, inquiry-based science is built into our DNA. PASCO started as a science fair project in my college dorm room, expanded into my family's garage, and ultimately grew into our headquarters in Roseville, California.

It has been very rewarding to work with talented educators for over 55 years. Today we are a global leader in hands-on science, as we serve educators and students in more than 100 countries. We work with individual instructors, science departments, and ministries of education to transform science education. And our solutions continue to be the choice of science and engineering programs at universities and colleges around the world.

On behalf of the entire PASCO team of almost 200 teachers, researchers, engineers, and professionals, and our Global Science Education Partners around the world, I thank you for your dedication to science education. We are ready to help you inspire the next generation of science learners, and we support you in preparing your students for their future.

Paul A. Stokstad | Founder

Paul at the science fair in 1962 with his prize-winning Millikan Oil Drop Apparatus

signature series

PASCO scientific | We Are Your Physics Lab Experts!

55 years PASCO

55 years of experience designing and manufacturing the highest quality physics equipment for teaching physics

Why Do Colleges and Universities Worldwide Come to Us for Lab Upgrades and Renovations?

Whether you are starting a new lab, renovating your existing one, or adding a single experiment, physics instructors around the globe rely on PASCO. With our state-of-the-art equipment, students can now perform classic physics experiments using the latest measuring technology.

- **Our Regional Sales Experts** understand your needs. We invite you to call and get to know your PASCO representative.
- **Our Staff of Physics Educators** can answer your most challenging questions. Call our Tech Support anytime you need our help.
- **Our Quality Apparatus** is covered by our 5-Year Warranty.

Your Most Trusted Source for Quality Physics Apparatus and Instrumentation

PASCO has decades of experience designing and manufacturing high quality physics equipment. Because our product development team includes physics instructors with classroom experience, we understand the challenges you face in your lab every day. The hardware and software we develop is specifically designed for just one thing: teaching physics.

About This Signature Series

We would like to share our journey and PASCO's product development history, from our very first product, the Millikan Oil Drop Apparatus, to our most recent iteration of classic physics experiments, such as Ampere's Law. The following pages will give you some insight into our creative process and help explain why physics teachers everywhere consider us first for their lab needs.

For more information on how we can help you in your physics lab, call 800-772-8700, or go to pasco.com/signature

PASCO Signature Series Products

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Complete Rotational System
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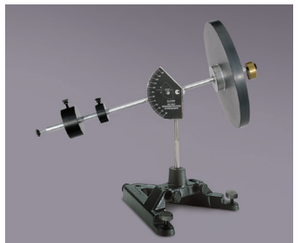
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850 Universal Interface
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PASCO capstone™ 2
Capstone 2
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Function Generator
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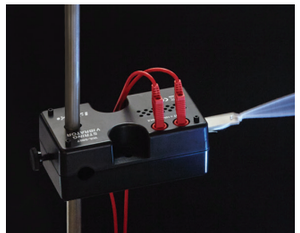
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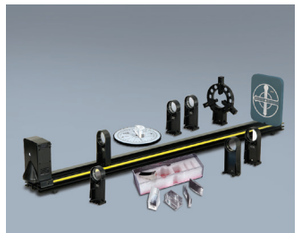
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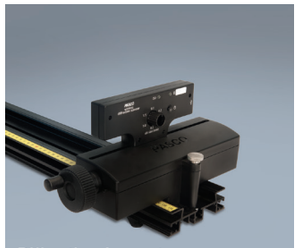
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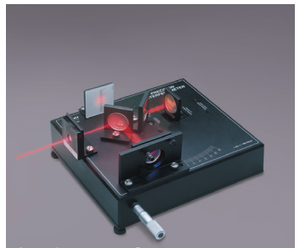
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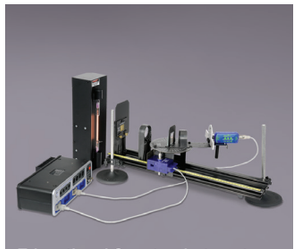
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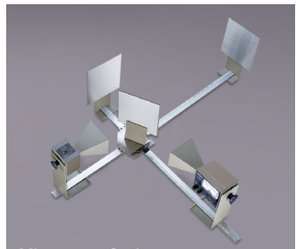
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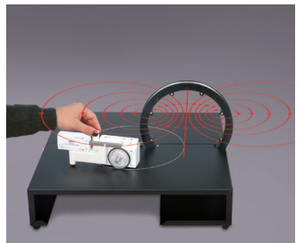
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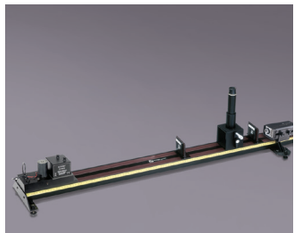
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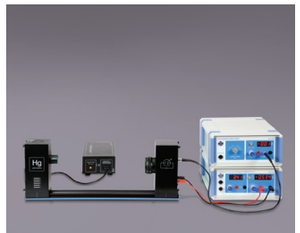
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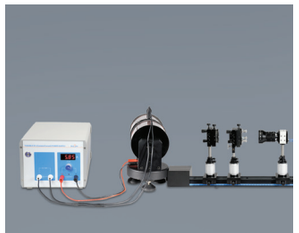
Zeeman Effect
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PASCO
Since 1964

1964 PASCO's first product:

MILLIKAN OIL DROP APPARATUS

a new MILLIKAN OIL DROP UNIT

This new apparatus has eliminated the major problems formerly encountered when performing the experiment. It provides:

EASE IN VIEWING DROPS

Illuminated scope reticle permits the use of a black field which provides high contrast between the background and illuminated drops.

PREMOUNTED LIGHT SOURCE AND SCOPE

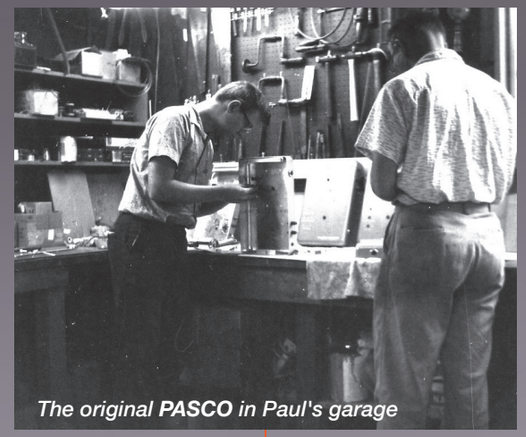
This eliminates the excessive time normally spent setting up and aligning other units, and permits completion of the experiment in a single laboratory period.

Plus: Shock-proof design, self-contained ionization source, atomizer, and complete instructions.

Price: $261.75 F.O.B. Factory

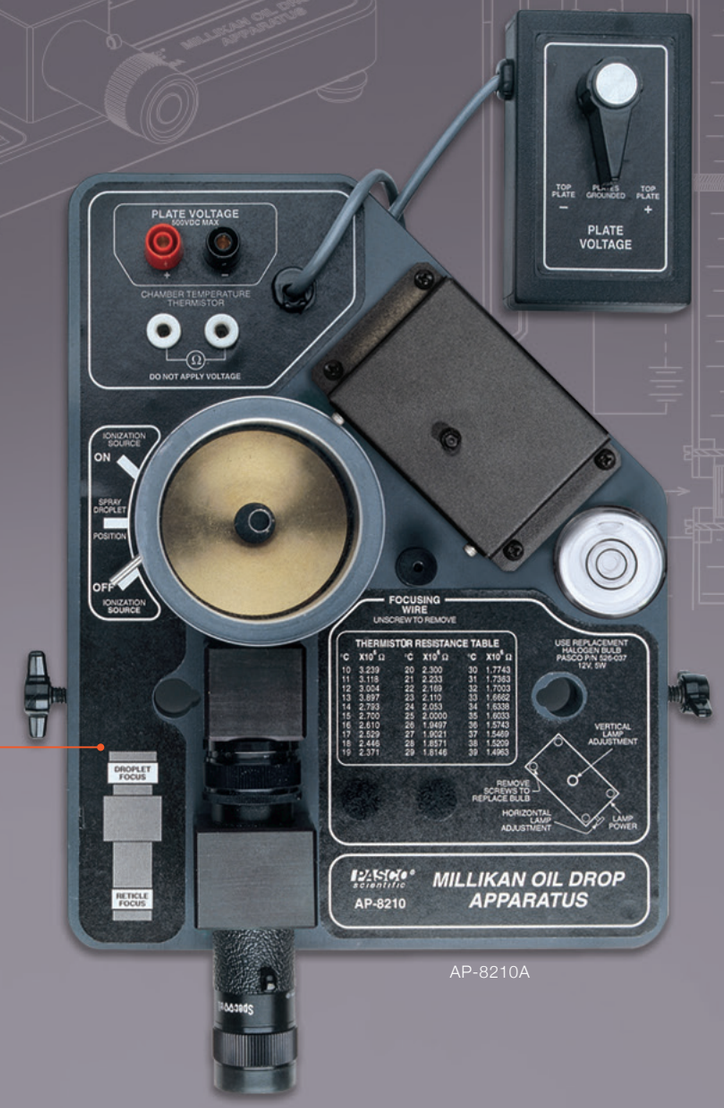
FOR INFORMATION WRITE:

PASCO scientific 769 Arroyo Ct. Lafayette, Calif.



*The original **PASCO** in Paul's garage*

*The **PASCO** team in 1975*



AP-8210A

KEY FEATURES

- Radioactive source to change the charge on the drop
- Bright LED lamp illuminates drops without heating the droplet chamber

pasco.com/signature

Our very first product, the **PASCO Millikan Oil Drop Apparatus**, began as a high school science fair project in 1962 and the first unit was sold in 1964. Its success established PASCO's reputation for innovation and dedication to science education.

THE BACKSTORY

- In the summer of 1964, several schools purchased 17 Millikan units. Just imagine… they purchased a product they had never seen, from a new company they had never heard of. We have never forgotten the tremendous amount of trust those teachers placed in us!
- The original Millikan design used Paul's brother's rifle scope for the viewing eyepiece. This scope was used in production units until the manufacturer stopped making them.

THE MILLIKAN OIL DROP EXPERIMENT

This experiment is one of the most popular experiments in undergraduate physics. It measures a fundamental constant using a method that won its originator, Robert Millikan, the Nobel Prize in Physics for his work on the photoelectric effect. The observation of the effects of one or more electrons upon oil drops in an electric field provides a striking demonstration of the quantized nature of electron charge.

THE BACKSTORY

- The original Millikan units have been around so long that their radioactive source has decayed through several half-lives. Paul recently refurbished some of these units for one of his original customers, installing new sources that have a much longer half-life.

PASCO Since 1964

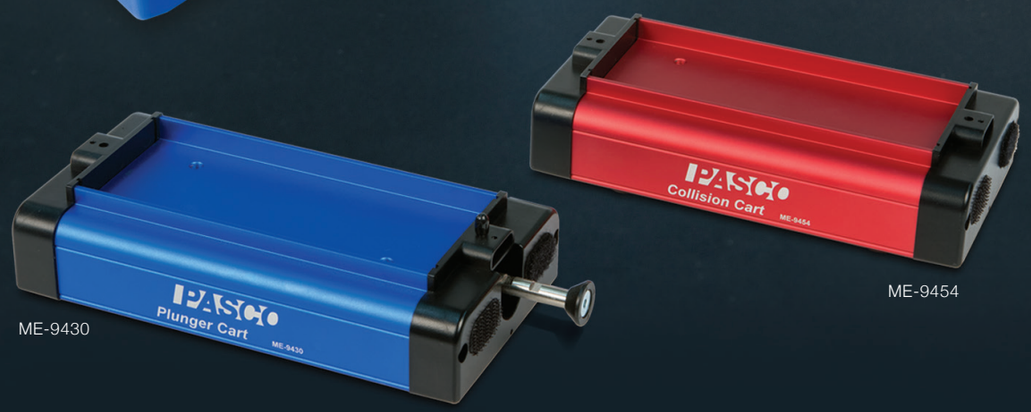
signature series

DYNAMICS SYSTEMS:
SIMPLY THE BEST

ME-1241

"The convenience and simplicity of not getting tangled up in the clutter of all those wires cannot be overstated. We expect the Smart Cart to usher in a paradigm shift in undergraduate physics laboratory instruction."

— Asif Shakur and Rainor Connor, Salisbury University, Salisbury, MD



ME-9454

ME-9430

WIRELESS SMART CART

Patent-pending

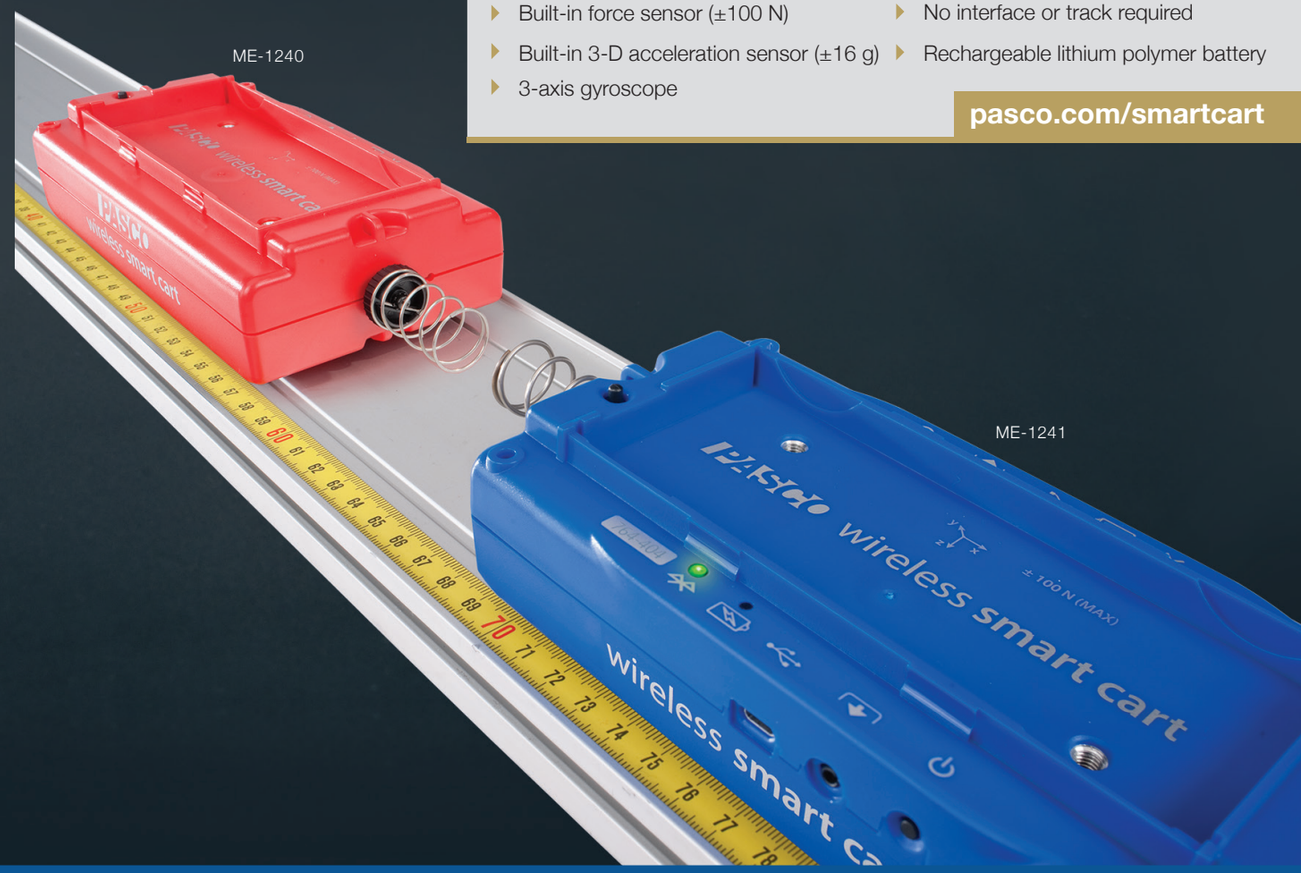
KEY FEATURES

- Optical encoder measures motion
- Built-in force sensor (±100 N)
- Built-in 3-D acceleration sensor (±16 g)
- 3-axis gyroscope
- Bluetooth® Low Energy technology
- No interface or track required
- Rechargeable lithium polymer battery

pasco.com/smartcart

ME-1240

ME-1241



THE HISTORY OF DYNAMICS CARTS

PASCO introduced the first **Dynamics System** in 1992, and we have been refining them ever since. We started with aluminum carts and tracks, and more innovations led to durable, lightweight polycarbonate carts and tracks. In 2016, PASCO revolutionized dynamics systems with the first fully instrumented, wireless dynamics cart: the Smart Cart. We still offer three carts (aluminum, polycarbonate, and Smart Cart) and two types of tracks (polycarbonate and aluminum). All are made to withstand the rigors of student use and include our 5-year warranty.

THE BACKSTORY

- Prior to the invention of the dynamics systems, there were only air tracks. When the dynamics systems were first shown at an AAPT conference, physics teachers' first question was, "Where is the air source?"

The Wireless Smart Cart: A Complete Physics Lab on Wheels

Here is the ultimate tool for your physics lab with built-in sensors to measure force, position, velocity, rotation, and acceleration. We are pleasantly surprised to find several articles in *The Physics Teacher* and the *American Journal of Physics* on new and interesting applications of the Smart Cart.

THE BACKSTORY

- With the early success of the low-friction Smart Pulley, we were buying bearings in bulk. PASCO's low-friction dynamics cart with its four bearing wheels was invented simply because Paul was searching for another product that would consume large quantities of bearings.

PROJECTILE LAUNCHER

ME-6800

MINI LAUNCHER

ME-6825B

The recently re-designed **Mini Launcher** has the same level of precision and accuracy as its predecessor, but it is now easier to assemble and adjust. And it provides built-in storage for the plunger and projectiles.

KEY FEATURES

- Three firing ranges
- Change launch angle without changing height
- Mini Launcher can launch at negative angles

pasco.com/signature

PASCO Projectile Launchers are a staple for any physics lab. Their durability and repeatability over time make them the most trusted launchers in the world.

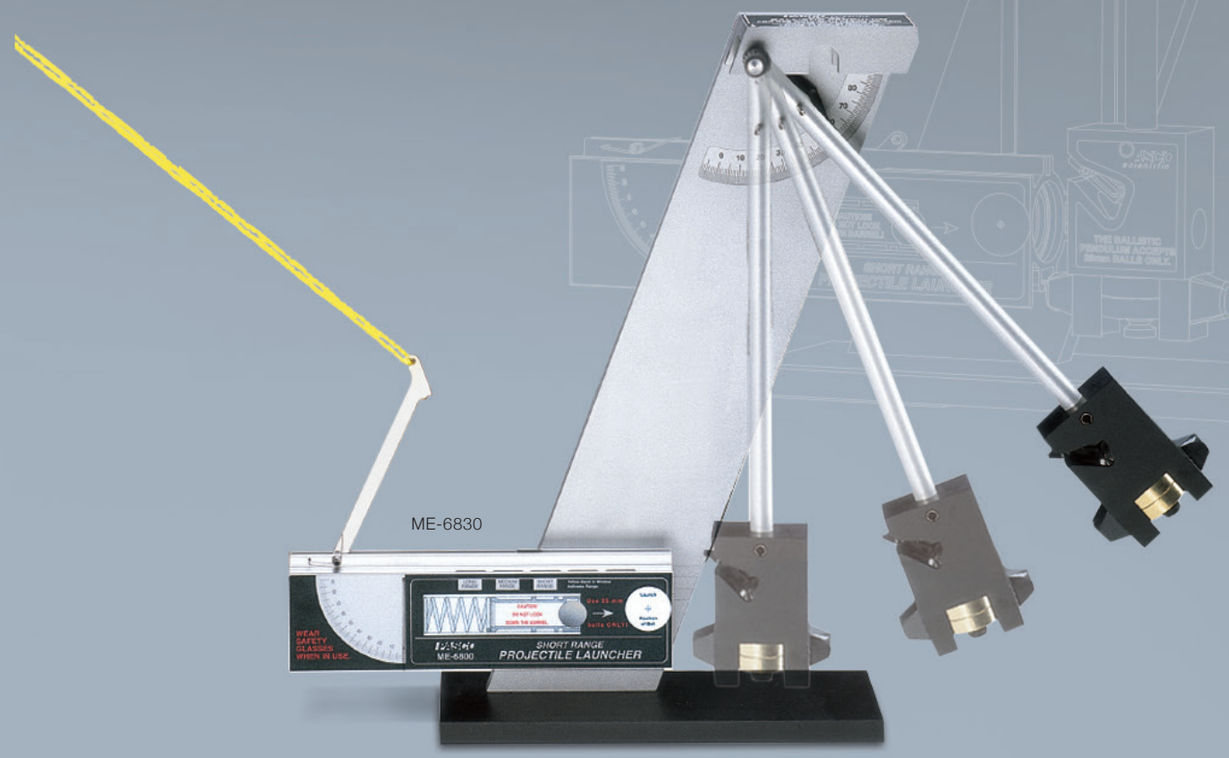
THE BACKSTORY

- Every Projectile Launcher goes through rigorous testing to be accurate, durable, and give repeatable results.
- One of our teachers put a silver dollar on the floor for his students, saying he would give them the dollar if they could hit it. Once he started using PASCO launchers, he stopped this practice because PASCO launchers proved to be so accurate that it was getting too expensive!
- Our launchers are simply referred to as the PASCO Launcher..."the definite article, you might say." – *The Fourth Doctor*

BALLISTIC PENDULUM

KEY FEATURES

- Uses the PASCO Projectile Launcher in this classic experiment.
- The 0-80° angle measurement scale resolves to 1/2°.
- Remove the pendulum to determine its mass and center of mass.
- Easily determine its rotational inertia by timing the pendulum oscillation.
- Reverse the pendulum so the ball bounces off for an elastic collision.
- Vary the pendulum mass.



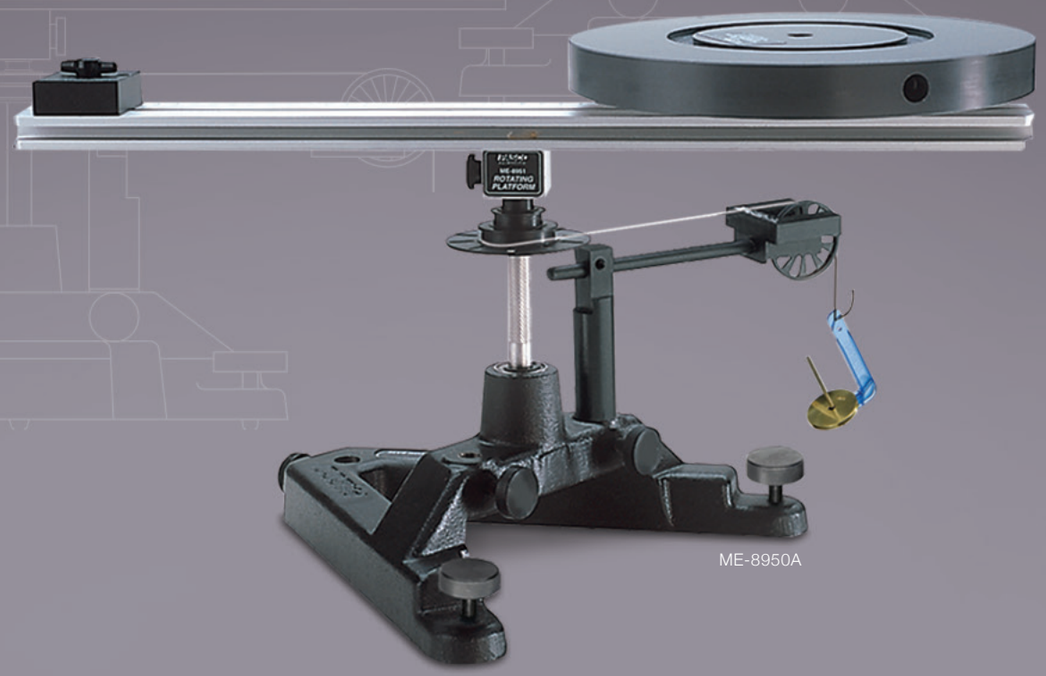
ME-6830

This **Ballistic Pendulum** experiment combines the laws of Conservation of Momentum and Conservation of Energy to determine the muzzle velocity of the projectile. Only simple mass and distance measurements are required to make this determination.

THE BACKSTORY

- During the development of the Projectile Launcher, each prototype was test-fired 10,000 times!
- We wonder how many people who buy our Projectile Launchers discover the included 2-D accessory that allows them to demonstrate independent *x-y* motion...
- The nylon balls were originally white. Paul tested different dye colors by cooking them in his kitchen to find the best color for physics lecture demonstrations.

COMPLETE
ROTATIONAL SYSTEM



ME-8950A

KEY FEATURES

- 4 kg cast iron base
- Dual ball bearings
- Stainless steel shaft
- Three-step pulley
- Disk can be rotated horizontally or vertically.

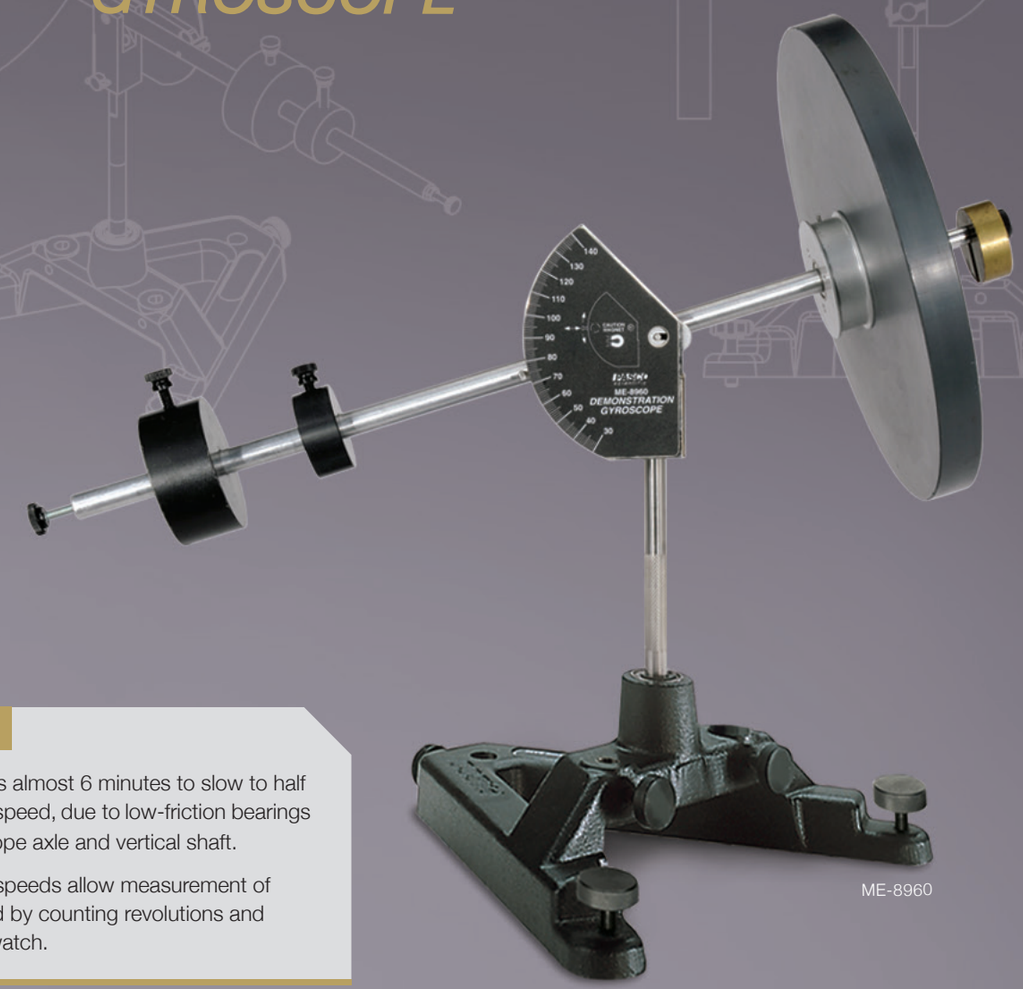
pasco.com/signature

PASCO's **Complete Rotational System** provides a range of experiments in centripetal force, angular momentum, and rotational motion. A unique set of accessories makes this an ideal tool for experiments in torque and rotational inertia.

THE BACKSTORY

- Some pieces of physics apparatus just need to be heavy. This one is made from cast iron and built with heavy-duty bearings.
- The three-step pulley used in this system was the first molded plastic part that PASCO produced.

DEMONSTRATION
GYROSCOPE



ME-8960

KEY FEATURES

- The disk takes almost 6 minutes to slow to half of its original speed, due to low-friction bearings in the gyroscope axle and vertical shaft.
- Low rotation speeds allow measurement of angular speed by counting revolutions and using a stopwatch.

The unique low friction and open design of PASCO's **3-Axis Gyroscope** allow studies of rotational motion never before possible with a commercial unit. The completely open design lets students stop precession by grabbing the vertical shaft and observing that the gyroscope dips. Rotational mathematics predicts the dipping action, but it could never be confirmed with traditional enclosed units.

THE BACKSTORY

- This product was inspired by a much larger version (built by Physics Professor Scott Perry) that used a bicycle wheel for the spinning disk.

850 UNIVERSAL INTERFACE

KEY FEATURES

- 10 MHz sample rate on two channels simultaneously
- Connect to computers via USB
- ±15 V at 1 A, DC to 100 kHz signal generator
- ±10 V at 50 mA, DC to 500 kHz independent signal generators
- Analog ports measure ±20 V, optional voltage gain 10x, 100x, 1000x
- Works with all PASPORT and ScienceWorkshop sensors as well as other PASPORT interfaces
- Requires Capstone software

The **850 Universal Interface** has all the speed and power you need for your most demanding physics experiments. And it can replace most of the equipment in your physics lab including oscilloscopes, power supplies, timers, function generators, multimeters, and more.

THE BACKSTORY

- At AAPT, one of our customers who had 750s asked. "When are you coming out with the 850?" That customer unwittingly named our newest interface!
- The 850 originally had three analog ports. But our users in France said they really needed four ports. We added the extra port and now call this "the French connection"!

550 UNIVERSAL INTERFACE

KEY FEATURES

- Up to 2 MHz sample rate on one channel
- Connect to computers or tablets via USB or Bluetooth®
- ±8 V at 400 mA, DC to 100 kHz signal generator
- Analog ports measure ±10 V, optional voltage gain 10x, 100x
- Works with all PASPORT and ScienceWorkshop sensors as well as other PASPORT interfaces
- 2 high-speed analog inputs + 2 digital inputs for photogates and other timing sensors + 2 PASCO PASPORT sensor inputs
- Requires Capstone or SPARKvue software

pasco.com/signature

The **550 Universal Interface** was designed with lower lab budgets in mind. It delivers the functionality of an 850 with reduced capabilities: It has PASPORT and ScienceWorkshop analog ports, as well as photogate ports and a signal generator that can power all your circuits. Additionally, the 550 can be connected via Bluetooth to computing devices that do not have USB.

THE BACKSTORY

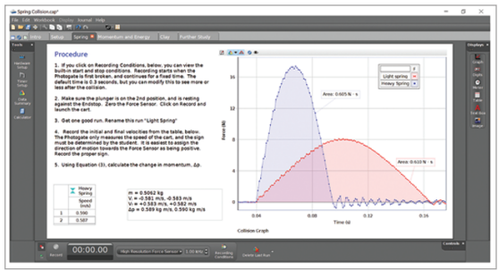
- The 550 is considered the "younger sibling" of the 850.
- Bluetooth was added to the 550 so that it would be compatible with mobile devices.
- These interfaces represent the evolution of the ScienceWorkshop 500 and 750 interfaces.

PASCO
Since 1964

signature series

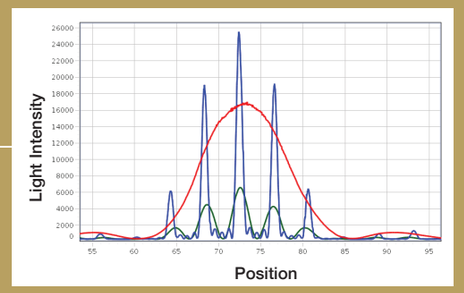
PASCO CAPSTONE 2 SOFTWARE

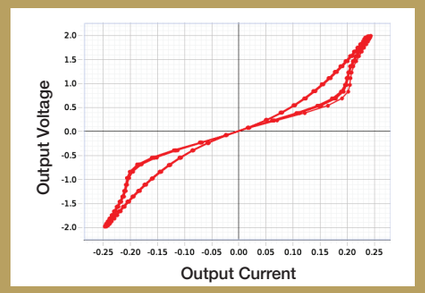
PASCO capstone™ 2

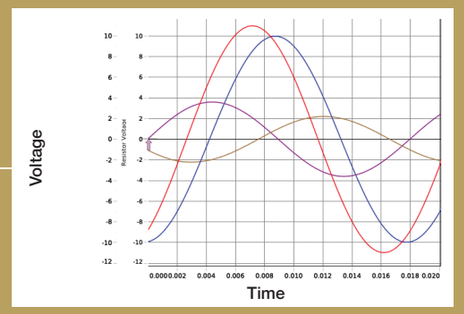


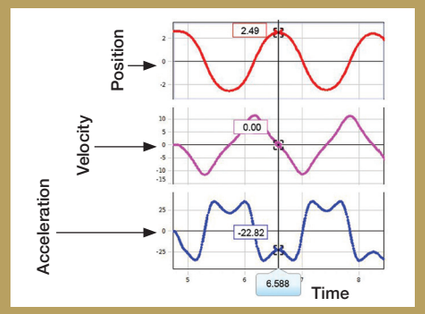
WHAT'S NEW

PASCO Capstone software has been designed specifically to collect, display, and analyze data in physics and engineering labs. Capstone works on Mac® and Windows® computers. Site licenses include school and student home use.

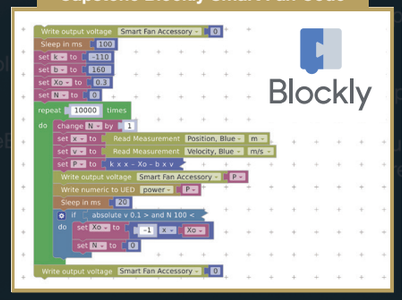








Capstone Blockly Smart Fan Code

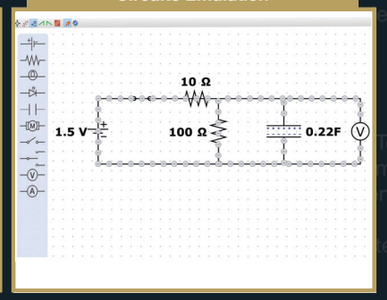


Trials Table

Trial Table: Vary Length/Mass of Pendulum

Trial	Run	Length (cm)	Mass (g)	Period (s)	Avg Period (s)	Avg Period ± (s)
1	1	45.00	70.05	1.353	1.354	0.003
	2			1.352		
	3			1.357		
2	4	30.00	70.05	1.147	1.149	0.004
	5			1.146		
	6			1.153		
3	7	15.00	70.05	0.946	0.945	0.001
	8			0.945		
	9			0.945		
4	10	45.00	7.19	1.344	1.340	0.004
	11			1.340		
	12			1.337		

Circuits Emulation



BASIC FEATURES INCLUDE:

- Works with all PASCO sensors: Wireless, PASPORT, and ScienceWorkshop
- Displays in graph, table, digit, meter, oscilloscope, text box, and picture
- Multi-coordinate tool
- Prediction tools

ADVANCED FEATURES INCLUDE:

- Video analysis
- Calculator
- Versatile tables
- Error bars
- Weighted linear fit

pasco.com/capstone

THE BACKSTORY

- When we developed the 850 Interface, it was so powerful that we had to create Capstone to manage the large amounts of data it could collect.

THE BACKSTORY

- We listen to teachers and students to understand how we can improve Capstone.

PASCO Since 1964

signature series

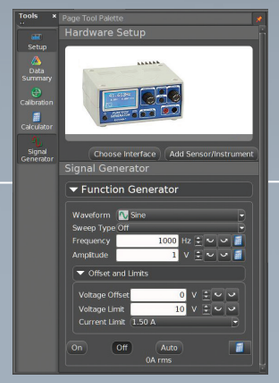
FUNCTION GENERATOR

KEY FEATURES

- High power (±10 V at 1 A)
- Frequency resolution over entire range: 0.001 Hz
- Waveforms: sine, triangle, square, positive/negative ramps, DC
- Stand-alone operation or Capstone software-controlled
- Frequency sweep

pasco.com/signature

PI-8127

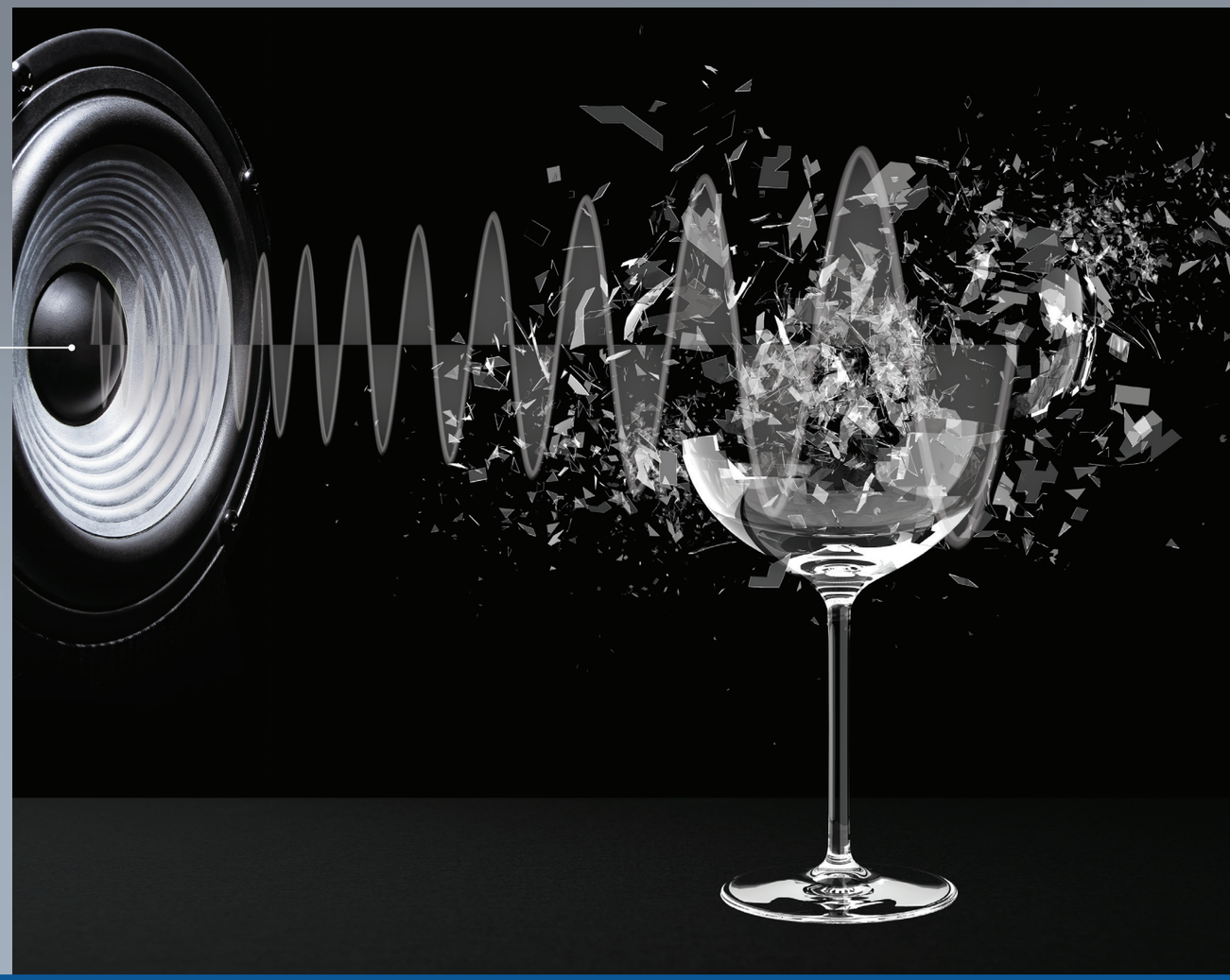


The **Function Generator** outputs sine, square, triangle, and positive and negative ramps with a frequency range of 0.001 Hz to 150 kHz, in addition to DC. Its powerful output (1 A at ±10 V) makes it useful for driving speakers, string vibrators, and circuits.

THE BACKSTORY

- With hundreds of signal generators available on the market, why do universities continue to buy the **PASCO Function Generator**? The reason is that it has the features needed for teaching physics that a bench signal generator will never have. We listen to our fellow physics teachers and give them the features they have requested.

INSTRUMENTATION FOR PHYSICS LABS



THE BACKSTORY

- We heard from lab managers on TAP-L that our initial design couldn't shatter a wine glass, so we updated the firmware to resolve to 0.001 Hz. Now physics teachers everywhere are happily shattering wine glasses!
- The engineer who designed this function generator also does our sensor firmware. So when he needed a way for teachers to update the function generator's firmware, he just made the whole thing controllable from Capstone, thus expanding its capabilities to include the ability to control the output with sensor-based calculations.

STRING VIBRATOR

Featuring an elegant design with no motors or speakers, the **String Vibrator** allows students to study the fundamental characteristics of mechanical waves including wave speed, frequency, wavelength, amplitude, interference, and resonance.

WA-9857A

STROBE SYSTEM

ME-6978

SINE WAVE GENERATOR

WA-9867

KEY FEATURES

- The design of the **PASCO String Vibrator** allows for well-defined nodes.
- The **PASCO Strobe System** can run up to four strobe modules.
- The **Strobe** can be triggered using a photogate.

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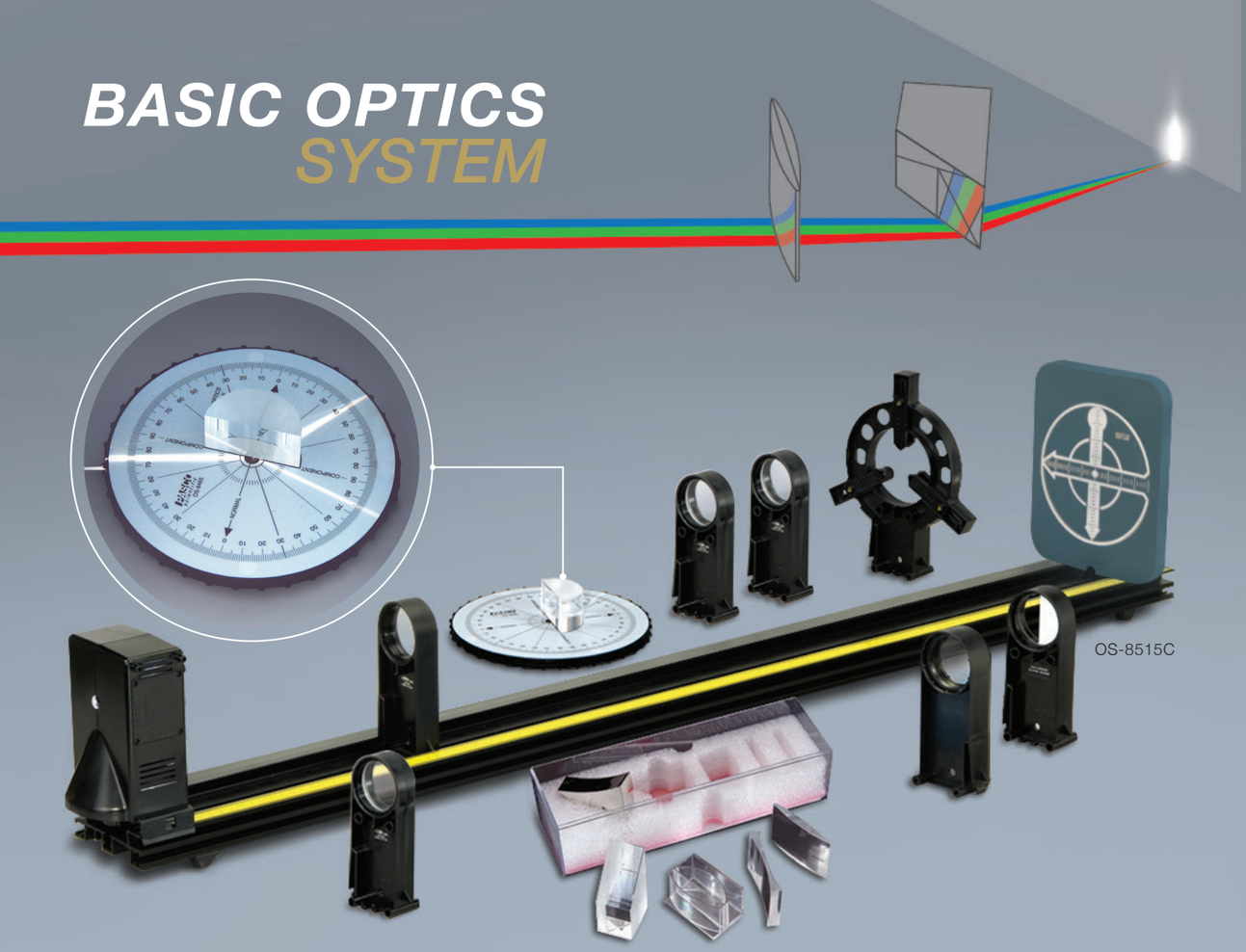
The **Sine Wave Generator** is an excellent tool for generating waves with speakers or wave drivers. It allows both the frequency (1-800 Hz) and amplitude of the sine wave output to be varied. It has onboard memory, which can store a fundamental frequency. Once stored, a single button press will double that frequency, which allows you to step through the harmonics. In addition, the generator can "learn" the fundamental frequency for a particular configuration.

The **PASCO Strobe System** has a combination of flexibility and low cost that makes it ideal for any situation where you want to "slow down" moving objects for a closer look. Another advantage is that it keeps the majority of the light on the object in question rather than light up the background, as so many traditional strobes do.

THE BACKSTORY

- After years of trying to illuminate a long vibrating string in class with a single point strobe, our teachers developed the idea of a string of strobes that could be placed anywhere. These can even be mounted on rod stands.

BASIC OPTICS SYSTEM



OS-8515C

KEY FEATURES

- 4-in-1 Light Source:
  - Acts as a point light source
  - Includes 1, 3, or 5 parallel rays
  - Has red-green-blue rays
  - Has a lighted crossed-arrow target with metric scale for focusing images
- Adjustable Lens Holder: Use your own lenses (from 19 mm to 75 mm in diameter) or choose from our lens sets.

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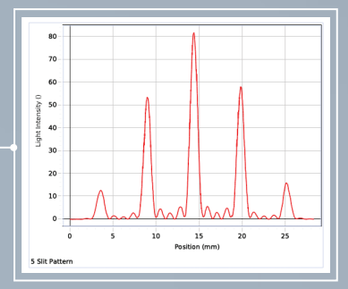
DIFFRACTION APPARATUS

OS-8439

KEY FEATURES

- Integrated Bluetooth® light and position sensors
- Precision hand-driven translator
- Diffraction slit wheel features metal-deposition diffraction patterns on glass
- Slit selections click into position



PASCO's **Basic Optics System** is another staple of the university physics lab. The rugged design allows for years of use studying geometric bench optics and table ray optics investigations. And it comes complete with everything you need to teach basic optics principles.

THE BACKSTORY

- PASCO made the first sensor-based diffraction apparatus. When our product developers showed Paul the first working prototype, the data was so good that he did not believe it was real. He interrupted the data collection by inserting his hand and blocking the laser beam, which proved to himself that the results were indeed real.

PASCO
Since 1964

signature series

RIPPLE TANK SYSTEM

KEY FEATURES

- Integrated strobe/ripple generator simplifies operation.
- Small frequency difference can be created so waves appear to move slower.
- The frequency range (1.0 Hz to 50.0 Hz) includes those important low frequencies that make refraction more prominent.
- Simple switch function changes rippler phase from 0 to 180 degrees.
- Voice coil actuators offer precise and silent operation.
- LED digital frequency readout is viewable in low lighting.
- White LED light source remains cool during use, producing a bright clear wave pattern.
- Included diffraction barriers (3) can be used to create a double slit.

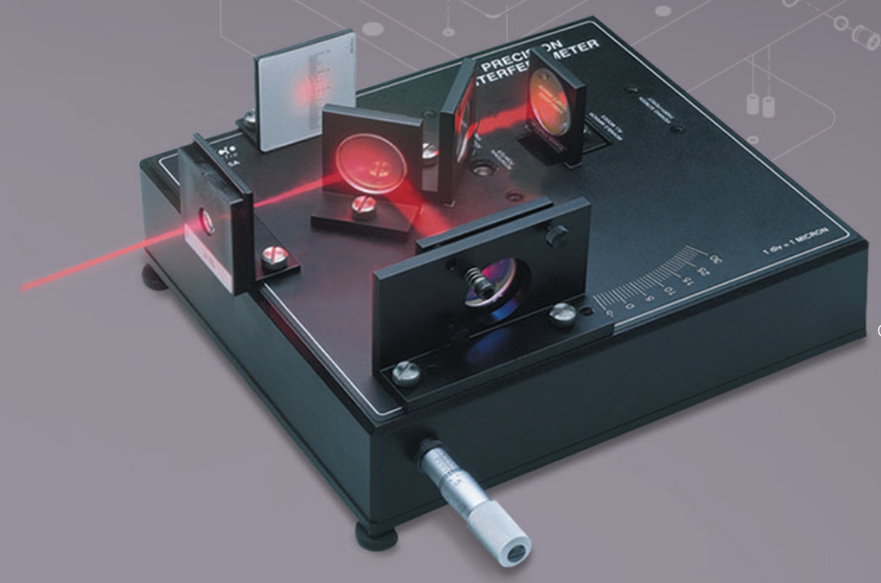
pasco.com/signature

WA-9899

INTERFEROMETER SYSTEM

KEY FEATURES

- Stable: The massive (5 kg) base is machined from a single block of aluminum, ensuring extremely stable optics.
- Smooth Mirror Movement: With the taut-band suspension system, there's no starting or stopping friction and virtually no backlash (less than 0.5 micron).
- Precise Measurements: Mirror control is extremely fine—one micron per division of the micrometer head. The mirrors and beam-splitter are flat to 1/4 wavelength to ensure uniform interference patterns.
- Larger Optics: The 3.2 cm (1.25") diameter optics in the PASCO Interferometer produce larger and sharper interference patterns for better experimental results.
- Complete: The Basic Interferometer includes everything necessary to perform basic Michelson and Fabry-Perot interferometry.



OS-9258B

This all-new **Ripple Tank System** is the ultimate wave interference design for a lecture demonstration. The foam "beach" design dramatically reduces reflections from the walls of the ripple tank, providing quality experiments at an affordable price. If you study wave propagation, reflection, refraction, or diffraction, this completely redesigned ripple tank system is a necessity in your lab.

THE BACKSTORY

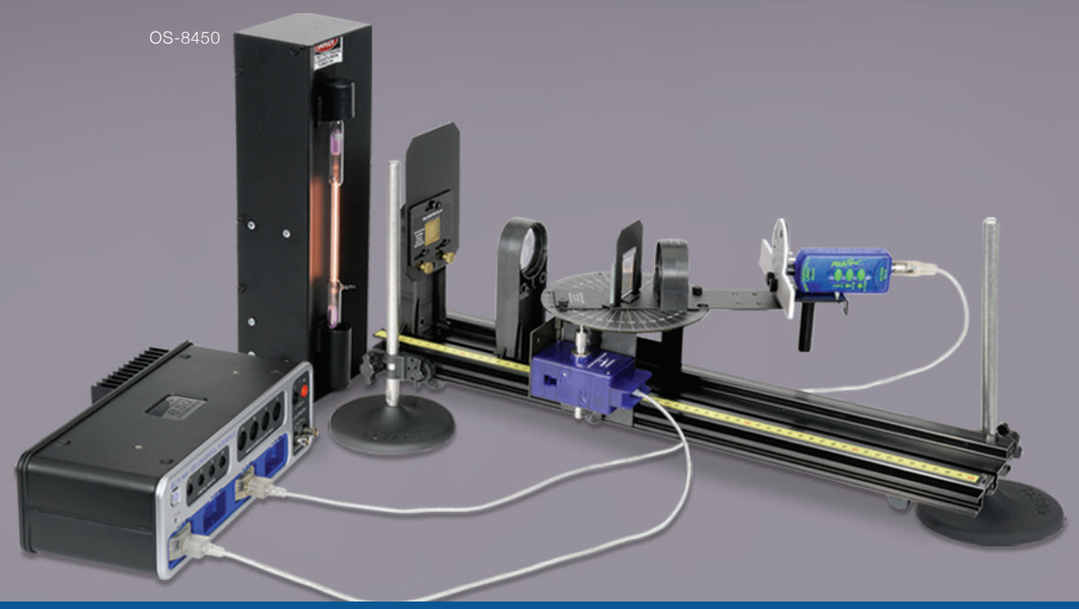
- The redesigned Ripple Tank was first demonstrated at AAPT in rainy Seattle. Our booth was very brightly lit, making it difficult to see the ripples. Luckily for us, AAPT was handing out umbrellas, which we were able to use to shade our apparatus.

The **PASCO Interferometer** is a high-precision, movable-mirror interferometer that can be used to perform Michelson, Fabry-Perot and Twyman-Green interferometry. Mirrors are attached with thumbscrews, so it's easy to set up and change configurations.

EDUCATIONAL SPECTROPHOTOMETER
ATOMIC SPECTRA

KEY FEATURES

- Open design allows students to see the spectrum while they scan it
- Lenses are coated to reduce reflections
- High quality grating: 600 lines/mm, strongly blazed in the first order



PASCO's Educational Spectrophotometer teaches basic optics principles and allows quantitative measurements rivaling those of more expensive units. When this spectrophotometer is used with PASCO Capstone, students can explore the relationship between angle, wavelength, and intensity and graph the spectral lines from discharge tubes. Lines from mercury, sodium, helium, neon, krypton, and argon can be plotted—even the lines of the Balmer series in hydrogen can be detected.

THE BACKSTORY

- When this product was first shown at an AAPT event in Denver, a physics teacher asked what it would be like to look at the spectrum of the sun. Our answer was, "Let's try it." We took it outside, scanned the sun's spectrum, and were able to see the absorption lines.
- To test this spectrophotometer, we used various tree leaves (a green leaf as well as a deep purple one from a plum tree) to see the absorption band of chlorophyll. Both leaves, while different in color, showed the same absorption band.

MICROWAVE
OPTICS

KEY FEATURES

- Diffraction Slit Hardware: Spacers and holders for performing interference experiments
- Ethafoam® Prism with Styrene Pellets: Used for refraction of microwaves; the index of refraction of styrene is determined.
- Rotating Mounts: The transmitter and receiver rotate through a full 360° (an important feature for polarization experiments).
- Gunn Diode Transmitter: A stable, low-voltage source of linearly polarized microwaves (10.5 GHz, 15 mW)
- Long-Arm Goniometer: For easy setup and alignment, the built-in degree and millimeter scales ensure accurate measurements.

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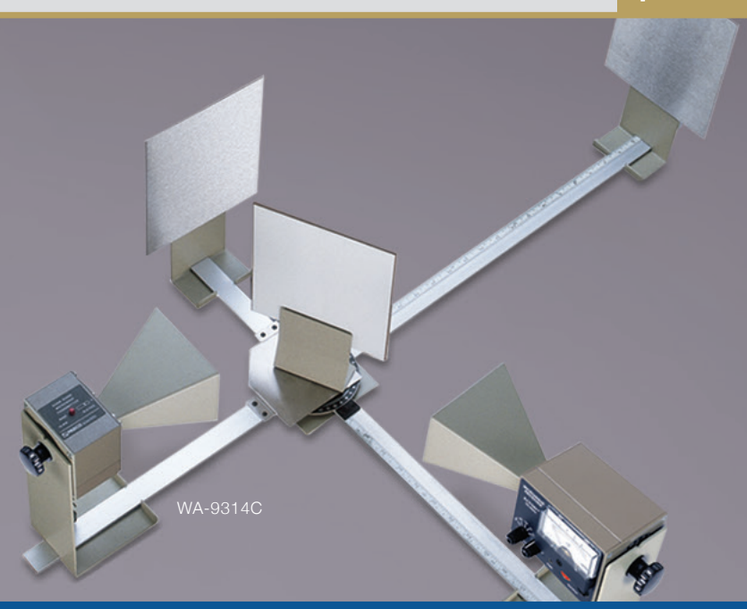

The heart of the **Microwave Optics System** is the Gunn Diode Transmitter and Receiver. The transmitter is a low-voltage source of linearly polarized microwaves (10.5 GHz, 15 mW). As the microwaves are reflected, refracted, diffracted, or directed through polarizers, the receiver can detect and measure the intensity of the microwaves at various positions beyond the transmitter. The receiver has a built-in amplifier as well as a variable sensitivity scale, ensuring accurate data for even the lowest intensity measurements.

THE BACKSTORY

- This is a perfectly true story: One day, a woman from Colombia showed up at PASCO with a suitcase full of cash. She wanted to purchase physics equipment to take back to Colombia. As it turned out, her husband was a physics teacher equipping labs in Colombia. Today, their children carry on the family business, although they no longer use suitcases for their transactions!

BASIC ELECTROSTATICS SYSTEM

KEY FEATURES

The PASCO **Basic Electrostatics System** includes all the components necessary for a quantitative investigation into the basics of electrostatics. With this integrated set of equipment, students can study:

- Production of charges, equal and opposite
- Charge by induction
- Principle of the Faraday Ice Pail
- Charge transfer
- Charge distribution in electric fields
- Capacitors and the Q = CV relationship

The Electrometer both improves the effectiveness of existing electrostatics demonstrations and permits many new experiments. The traditional measuring device for electrostatics, an electroscope, is only roughly quantitative and does not indicate polarity.

THE BACKSTORY

- The synthetic fabric supplier for The Hanes® Pantyhose company contacted us because they were trying to solve the problem of static cling in their pantyhose. So they used our Electrostatics System to quantify their problem. Alas, with the advent of anti-static fabric, they no longer required our system.

RING LAUNCHER

EM-8817

KEY FEATURES

- Launches ring straight up 2 meters
- Automatic thermal switch prevents overheating
- Includes induction coil with lamp to show wireless power
- Split ring produces null result to teach about induced currents

pasco.com/signature

In this classic demonstration of electromagnetic induction, an aluminum ring is propelled straight up a maximum distance of 2 meters. The changing magnetic field from the AC-powered coil causes a changing magnetic flux through the aluminum ring.

THE BACKSTORY

- At an AAPT meeting in 2005, we were approached by a member of the U.S. Naval Academy, who asked us to co-develop this product. The Ring Launcher design was contributed by Carl Schneider and John Ertel at the U.S. Naval Academy. Their design was so powerful that we had to tone it down so the ring would not hit the ceiling of the common classroom.

AMPERE'S LAW EXPERIMENT

$$\oint \vec{B} \cdot d\vec{l} = \mu_o NI$$

KEY FEATURES

- Wireless (untethered) sensors
- Students can measure the magnetic field tangent to a closed loop integral of ANY path.
- Large aluminum table

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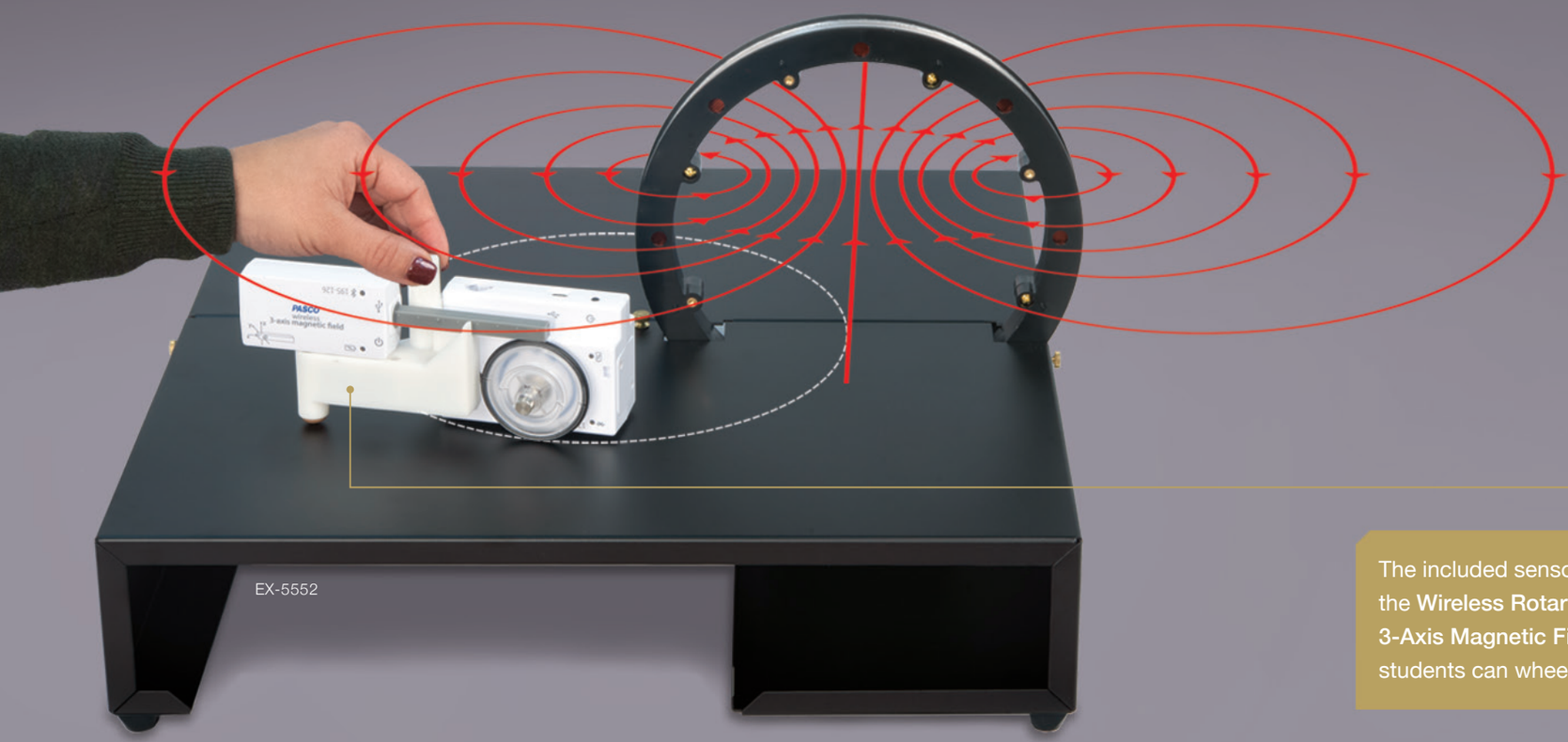


The included sensor bracket connects the **Wireless Rotary Motion** and **Wireless 3-Axis Magnetic Field** sensors (included) so that students can wheel them around along a closed path.

Another PASCO first! Students can experimentally verify **Ampere's Law** by graphing the magnetic field strength tangent to the path taken along a closed path that encloses a current. This is made possible by a bracket that mounts a Wireless Magnetic Field Sensor and Wireless Rotary Motion Sensor together. Students can push the coupled sensors together, measuring the magnetic field along a path. Then students can compare the area under the curve to the amount of current enclosed in the path.

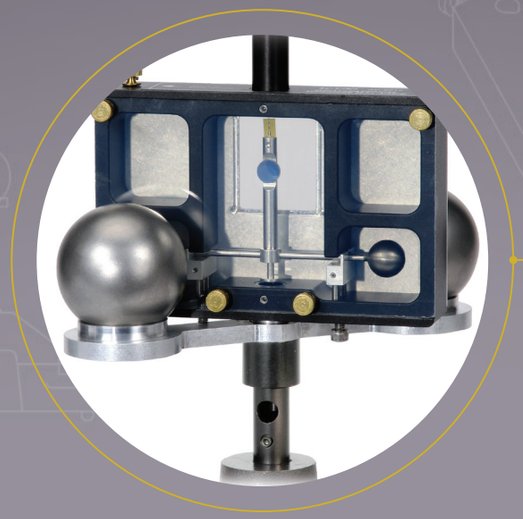
THE PASCO ADVANTAGE

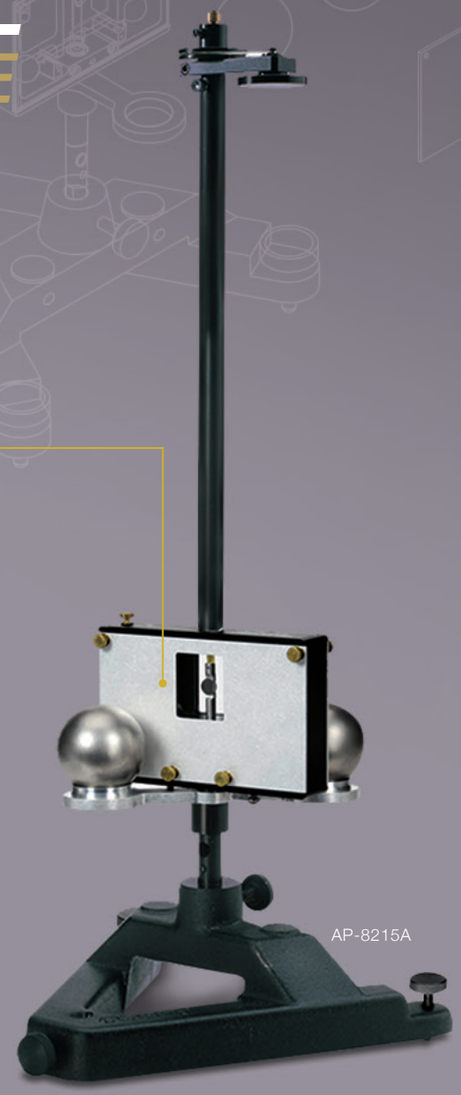
The **Wireless 3-Axis Magnetic Field** and **Wireless Rotary Motion** sensors allow students to move in any shaped path without wires getting wrapped around the coil. Students can choose any path they want; they don't have to follow a circular path because the sensors are recording the field tangent to any path.

THE BACKSTORY

- We developed the concept for this product in the 1990s, but it didn't become viable until the advent of wireless technology. Imagine what other ideas we have been kicking around for years!

GRAVITATIONAL TORSION BALANCE





AP-8215A

KEY FEATURES

- Unique leveling sight allows a view up the center shaft
- Conductive shields eliminate electrostatic effects
- Easy Torsion Band Replacement (spare included)

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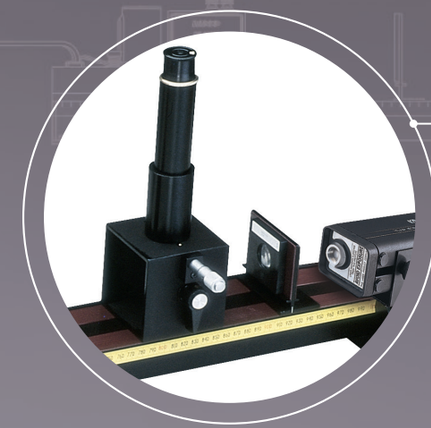
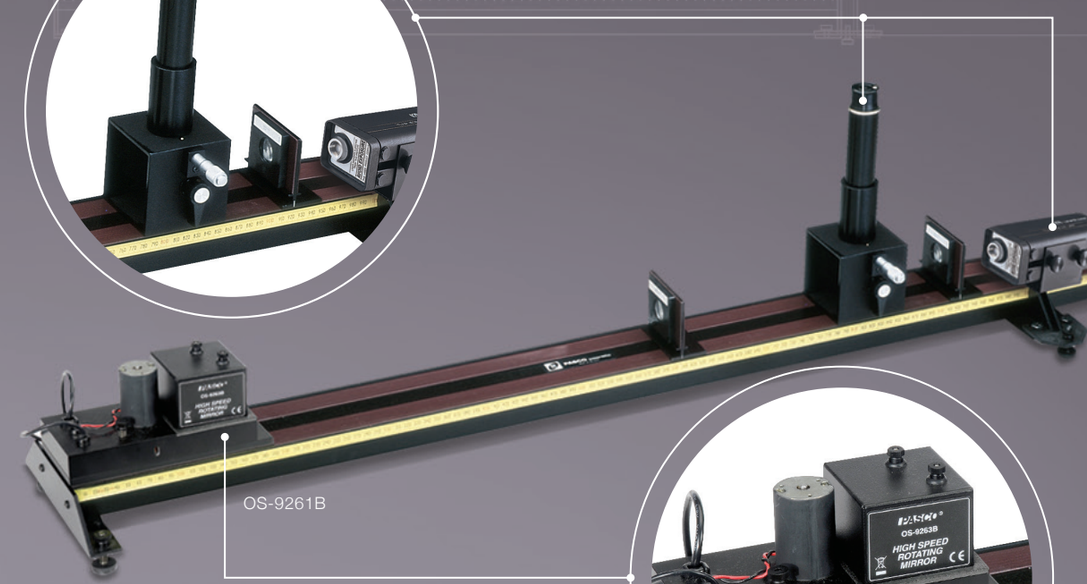
Following Cavendish's classic design, PASCO's **Gravitational Torsion Balance** combines features that significantly improve ease of setup, durability of the torsion band, and the quality of results. (This is PASCO's most sensitive apparatus. During data collection, care must be taken to prevent disturbing its operation. Opening and closing doors and sudden changes in room ventilation can disturb this precision instrument. We have recently updated this experiment to use video analysis, which greatly speeds up the data collection.)

THE BACKSTORY

- The filament for the torsion band is custom-made for PASCO. A small spool costs so much that we keep it in a vault in the storeroom, so no one will accidentally mistake it for common wire.
- According to our product developer, it took "two years of blood, sweat, and tears" to bring this product to market.

SPEED OF LIGHT APPARATUS





OS-9261B

Includes

- Historical Foucault Experiment
- Spinning Mirror 90,000 rpm
- He-Ne Laser Light Source

This apparatus uses the Foucault Method to measure the speed of light. The first observation is made when the rotating mirror is not rotating. The second observation is made when the rotating mirror is rotating. The displacement between the first and second observations is proportional to the transit time of the light over the distance and to the angular velocity of the rotating mirror.

THE BACKSTORY

- When this apparatus was first built, we glued a mirror to the spinning shaft. But at 90,000 rpm, we soon discovered that we couldn't center the mirror precisely, so now the mirror is highly polished metal, which is precision-machined directly on the shaft.

PHOTOELECTRIC EFFECT

Includes

- Current Amplifier—Measuring range: 10^{-8} to 10^{-13} A, in six ranges
- Photoelectric Tube—Spectral response range: 300–700 nm; anode: nickel ring
- Five Optical Filters—Central wavelengths: 365.0, 404.7, 435.8, 546.1, and 578.0 nm
- Voltage Output for Photoelectric Tube—Voltage adjustment in two ranges: -4.5 V to 0 V and -4.5 V to +30 V; 4 digit display
- Data Collection—Collect data with an 850 or 550 interface and Capstone software.

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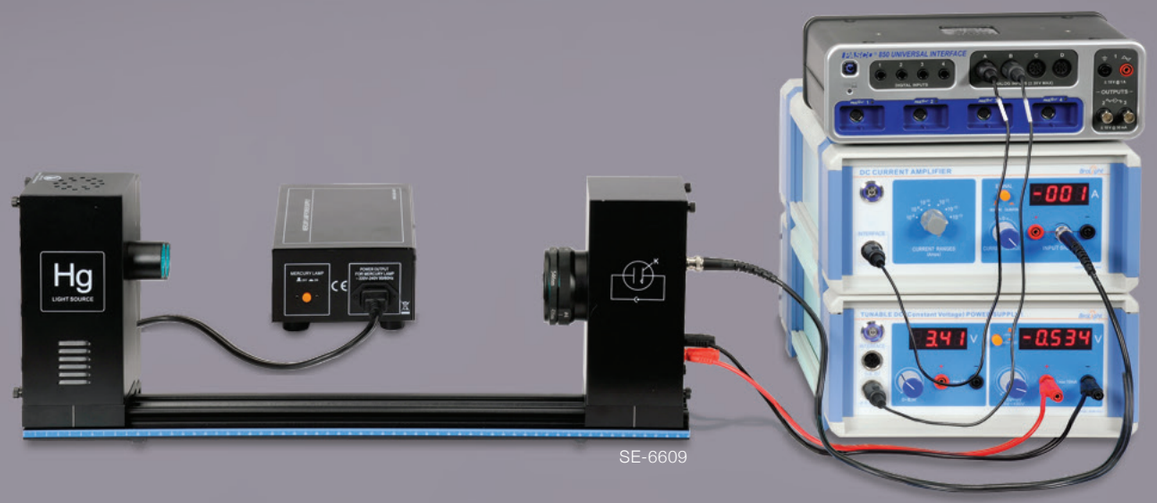


SE-6609

The **Photoelectric Effect System** is used to perform the photoelectric experiment, determining Planck's Constant to within 5%. This apparatus uses the conventional method of determining Planck's Constant. The metal plate in the photodiode is illuminated with various frequencies of light.

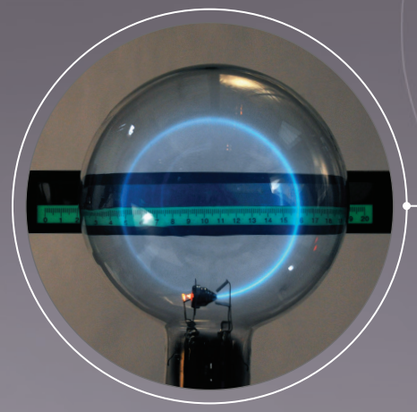
THE BACKSTORY

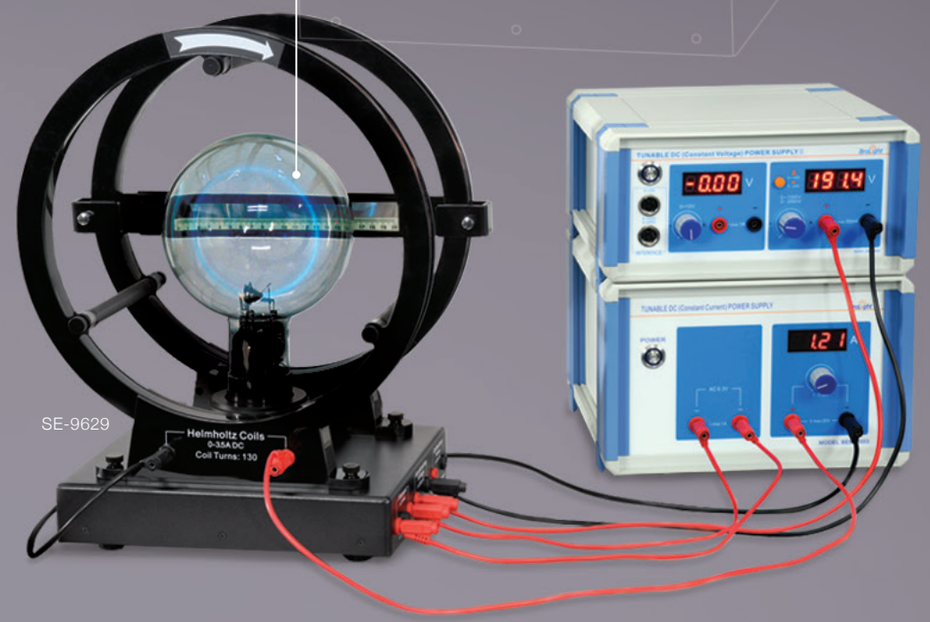
- PASCO's original photoelectric effect apparatus was based on a photodiode that was commercially used as part of an electric eye that opened doors. When the modern equivalent replaced it, we couldn't get the photodiode anymore and we had to redesign the entire apparatus around a new photodiode tube.

ELECTRON CHARGE -TO-MASS RATIO SYSTEM

KEY FEATURES

- Easily read the radius of curvature of the electron path.
- Electron tubes can be rotated through 90°.
- Study the effect of electric field using electron beam deflection plates.
- Collect data with an 850 or 550 interface and Capstone software.





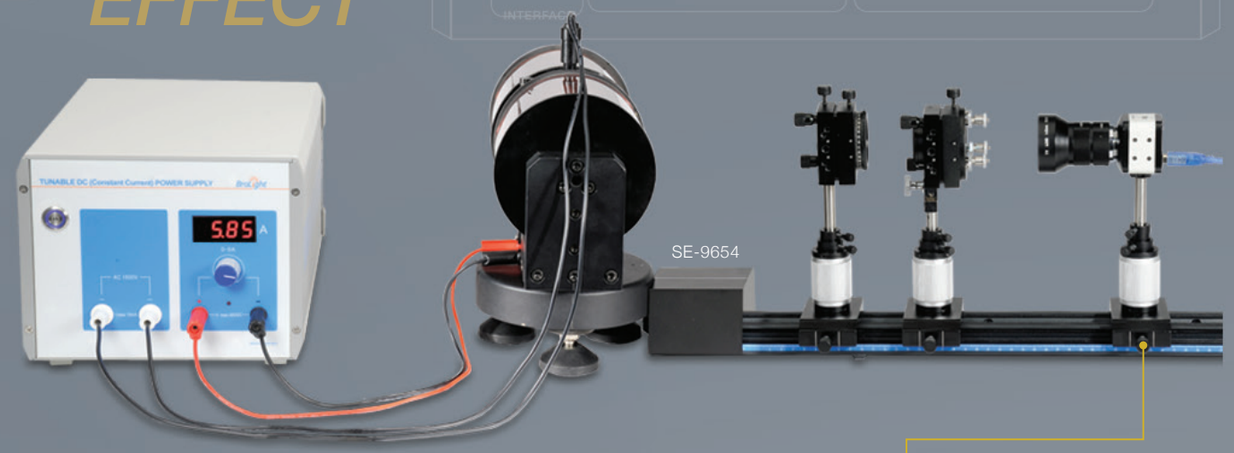
SE-9629

The **Charge-to-Mass Ratio System** reproduces one version of J.J. Thomson's landmark experiment, providing an accurate measurement of the charge-to-mass ratio of an electron. And, since the electron tube can be rotated through 90°, students can also make a more general study of the behavior of electrons in a magnetic field.

THE BACKSTORY

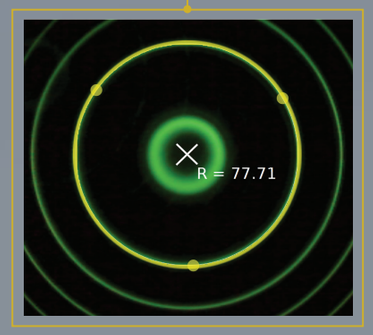
- This system was Paul's second science fair project. After his success with the Millikan Oil Drop Apparatus, he decided he really liked science fair competitions!

ZEEMAN EFFECT



KEY FEATURES

- CMOS Camera and Lens 2 M pixels
- Fabry-Perot Interferometer
- Interference Filter
- Mercury Pen Lamp
- Electromagnet 5 A, 1.2 T
- Horizontal Optical Mount (2-D)
- Precision Kinematic Optical Mounts (1-D)
- Analyze fringes with Capstone video analysis



In this classic experiment students observe the interference pattern from a Fabry-Perot interferometer that results from splitting the spectral line of a mercury lamp in a magnetic field.

THE BACKSTORY

- The circle tool for video analysis in Capstone was created specifically to measure the radii of the interference fringes in the Zeeman Effect.

FRANCK-HERTZ APPARATUS

KEY FEATURES

- Filling gas: argon
- No oven required
- Wave crest (or trough) number: 6
- Argon tube lifespan: ≤3000 hrs
- Automate data collection with an 850 or 550 Universal Interface and Capstone software.

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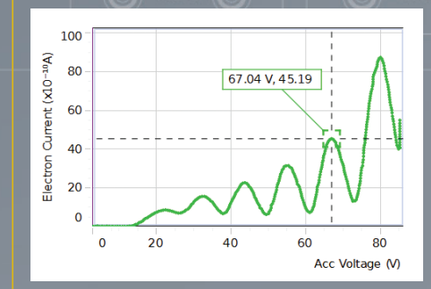

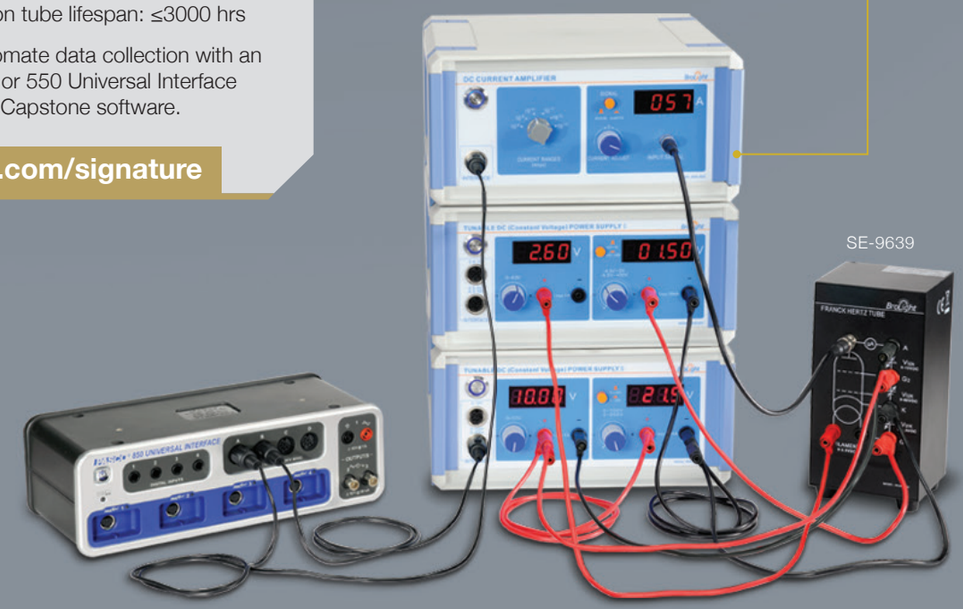

As early as 1914, **James Franck** and **Gustav Hertz** discovered in the course of their investigations an energy loss in distinct steps for electrons passing through mercury vapor and a corresponding emission at the ultraviolet line (λ = 254 nm) of mercury.

Electrons are accelerated by applying a known potential between two grids inside the argon tube. When an electron has sufficient kinetic energy to excite one of argon's outer orbital electrons and has an inelastic collision with an argon atom, the electron loses a specific amount of kinetic energy. This loss of electron kinetic energy causes a decrease in the electron current in the argon tube. Within a very short time, the excited argon electron will fall from the excited state back into the ground state level, emitting energy in the form of photons.

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Because we are the experts in physics apparatus and instrumentation.

THANK YOU

OUR SINCERE THANKS TO ALL THE PHYSICS TEACHERS

At PASCO, we rely on your feedback to continually improve (and sometimes fix!) our physics equipment. So we send a heartfelt "thank you" to all the physics teachers from AAPT, PTRA, PIRA, ALPhA, TAP-L, Modeling, PER, IPLS, and PTSOS who have sent us their comments and observations. We always want to hear from you!

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Isaac | Domestic National Sales Manager

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Mike | Technical Support

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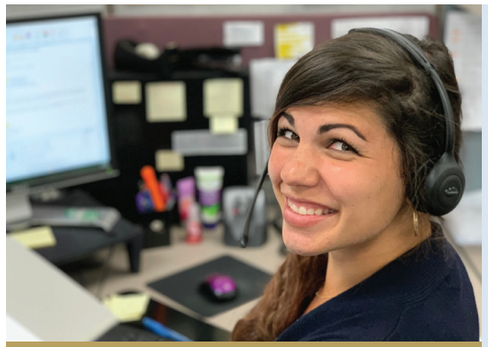

Sarah | Customer Service

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