

METER STICK PHYSICS

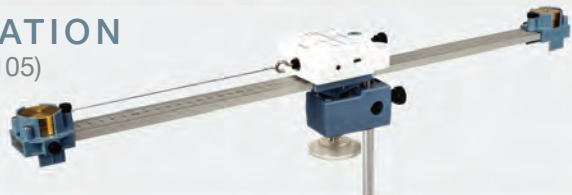
One Meter, Infinite Physics



OPTICS
(Page 307)



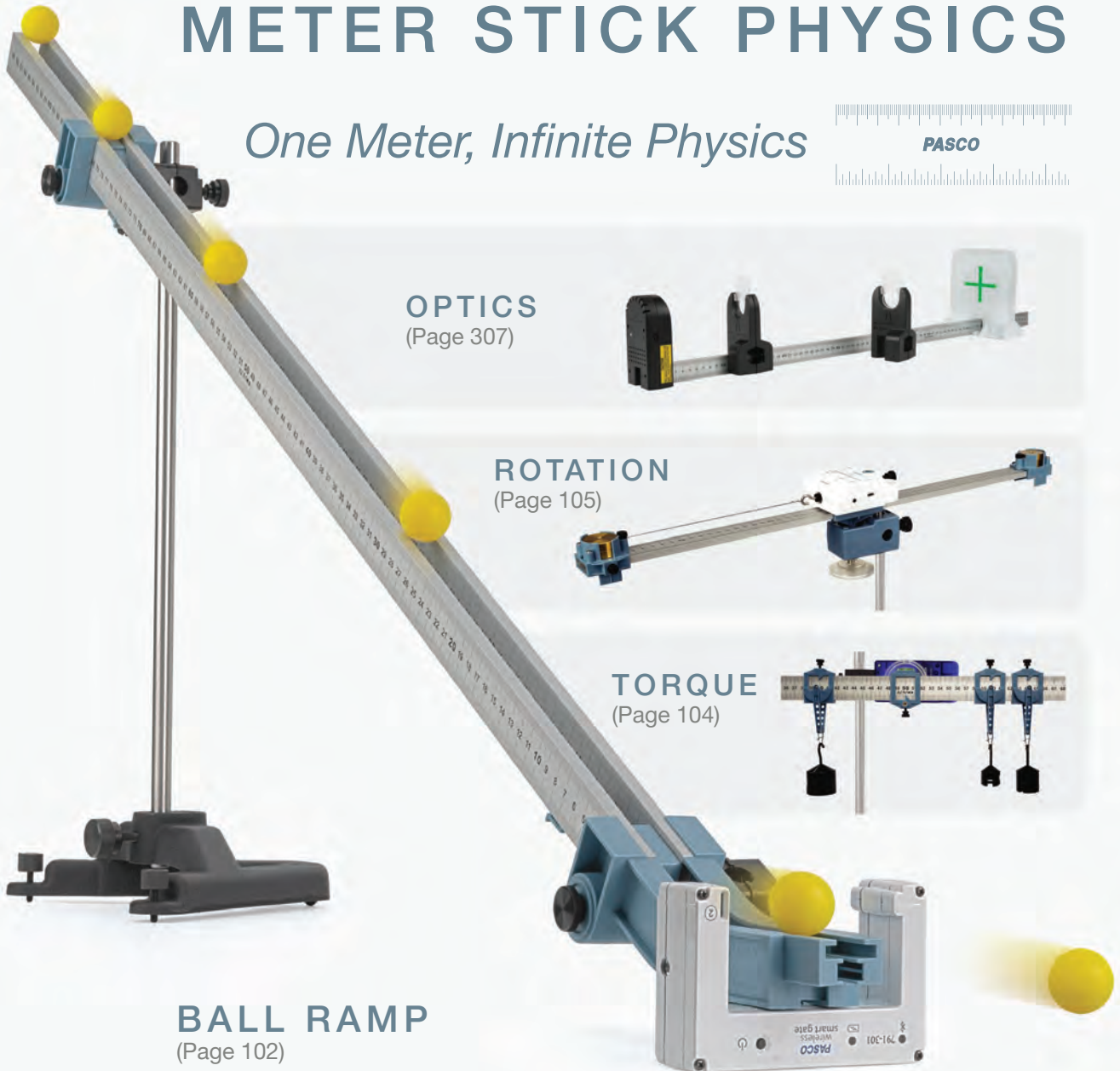
ROTATION
(Page 105)



TORQUE
(Page 104)



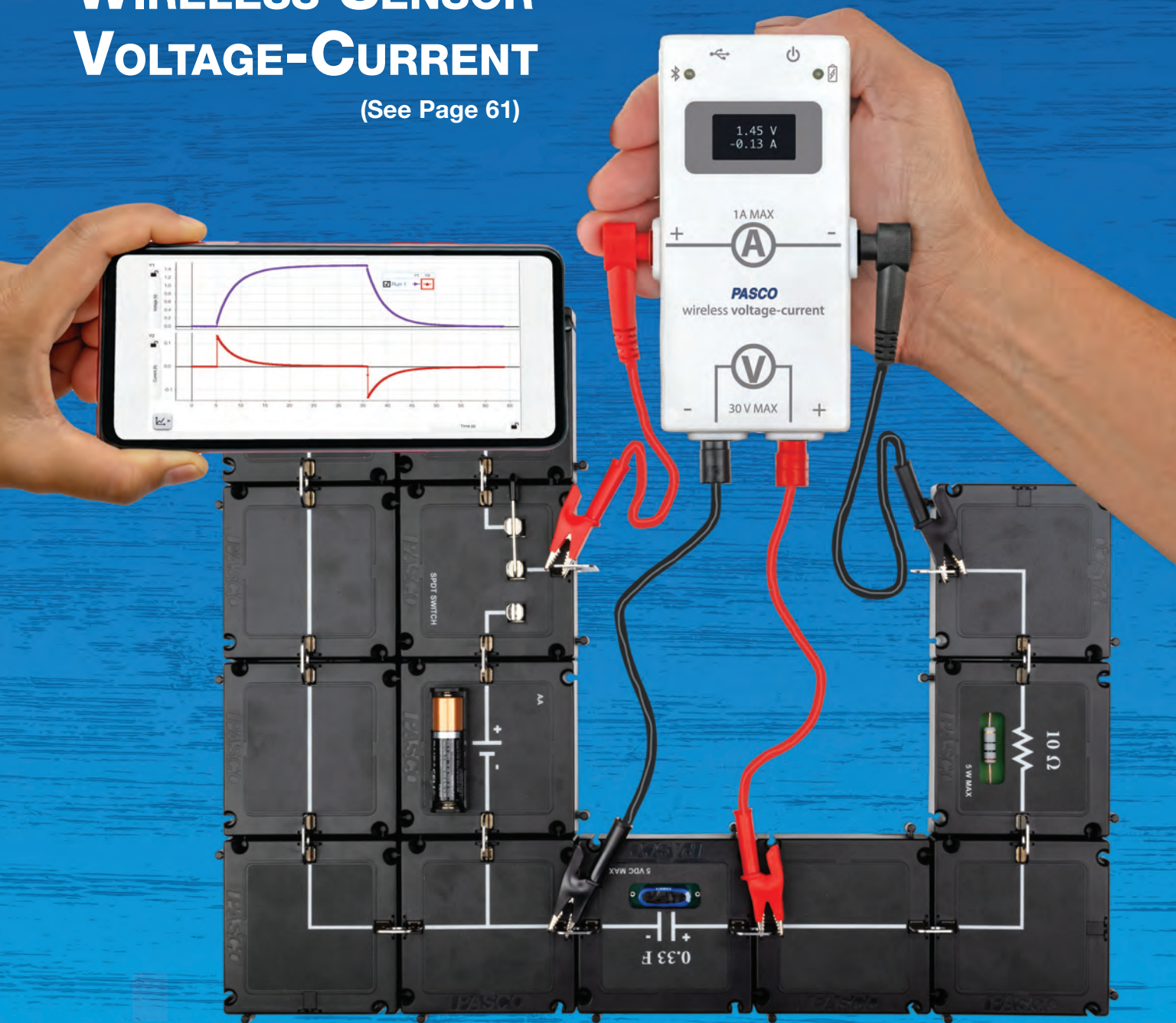
BALL RAMP
(Page 102)



NEW!

WIRELESS SENSOR VOLTAGE-CURRENT

(See Page 61)



The Wireless Voltage-Current Sensor is a smart alternative to a traditional multimeter. It can be used as a standalone unit by using the built-in display, or connected to a computing device to output measurements to PASCO software for graphical analysis.

Table of Contents

Page

PASCO Portal _____ **2-3**

New Products _____ **4-7**

Software _____ **8-15**

Sensors and Datalogging _____ **16-6**

Interfaces & Dataloggers _____ 16-23

Analog ScienceWorkshop Sensors _____ 24-30

Digital PASPORT Sensors _____ 31-47

Dataloggers _____ 48-50

Wireless Sensors _____ 51-69

Curriculum and Bundles _____ **70-81**

STEM Solutions _____ **82-101**

//code.Node Solutions _____ 85-87

//control.Node Solutions _____ 88-95

PASCObot _____ 96-101

Mechanics _____ **102-215**

Meter Stick Physics _____ 102-105

**Dynamics Systems
and Accessories** _____ **106-121**

Tracks & Carts _____ 106-109

Smart Cart _____ 110-111

Smart Cart Accessories _____ 112-117

PAstrack _____ 118

Dynamics Systems Accessories _____ 119-121

Measurement _____ 122-133

Freefall & Projectile Launchers _____ 134-143

Statics _____ 144-149

Human Applications _____ 150-151

Motorized Structures _____ 152-157

Structures Systems _____ 158-171

Materials Testing _____ 172-179

Hooke's Law & Springs _____ 180-182

Rotation & Oscillations _____ 183-197

Fluids, Pipe Network, & Density _____ 198-202

Lab Supplies _____ 203-215

Pulleys, Rods, Stands, & Clamps _____ 203-207

Spring Scales, Measuring, Balls, String,

Storage, Mass Sets, Stopwatches

& Balances _____ 208-215

Thermodynamics _____ **216-227**

Thermal Expansion & Conduction _____ 216-218

Calorimetry, Gas Laws, & Heat Engines _____ 219-224

Thermometers & Thermal Radiation _____ 225-227

Electromagnetism _____ **228-275**

Electrostatics _____ 228-234

Circuits & Supplies _____ 235-250

Generators _____ 251-253

Magnetism _____ 254-255

Power Supplies, Function Generators,
& Meters _____ 256-275

Waves & Sound _____ **276-287**

Ripple Tank _____ 276-277

Standing Waves & Resonance _____ 278-284

Wave Media & Tuning Forks _____ 285-287

Light & Optics _____ **288-322**

Basic Optics _____ 288-294

Color & Human Eye _____ 295-297

Diffraction _____ 298-303

Polarization _____ 304-306

Optics Systems & Components _____ 307-309

Spectrometers _____ 310-314

Light Sources & Sensors _____ 315-319

Interferometers _____ 320-321

Microwave Optics _____ 322

Fundamental Constants _____ **323-333**

Atomic & Nuclear _____ **334-338**

Experiments _____ **339-392**

Indexes _____ **393-407**

Part Number Index _____ 393-395

Product and Topic Index _____ 396-407

Order Information _____ **408**



PASCO PORTAL

FOR SCIENCE EDUCATION



*"Best Digital Ecosystem
for Teachers"*
Category



 **ClassLink**  **Clever**

SSO Support



Google Classroom



canvas
BY INSTRUCTURE



BRIGHTSPACE

Blackboard



schoolology

LMS Support

PASCO Portal is the first-of-its-kind digital environment, providing instructors and lab managers with ready-to-use activities, software, and teaching content suitable for core and supplemental curriculum. PASCO Portal is a convenient and flexible online platform that hosts your teaching resources and continuous professional development to facilitate all-inclusive instruction for science, STEM, and engineering programs.

PASCO Portal is compatible with any Learning Management Systems (LMS) that have been 1EDTech-certified, including Google Classroom, Canvas, Brightspace, Blackboard, and Schoology. It also supports authentication with Single Sign-On (SSO) through Google, Classlink, and Clever. If your institution's 1EDTech-certified LMS is not listed, contact us to initiate a new integration.

Sign up for **PASCO PORTAL** and realize the full potential of PASCO's hands-on science solutions.



Core Curriculum

Access and distribute Essential Science or OpenSciEd curriculum labs or assignments right within your Learning Management System (LMS).



Experiment Library

Search PASCO Portal's Lab Library which contains hundreds of engaging, standards-based lab activities for all science disciplines, including STEM.



Hands-on Solutions

Tap into PASCO's 21st Century lab equipment and technologies. Our hands-on solutions are more accessible than ever with PASCO Portal.



How-to Videos

Take advantage of a robust collection of how-to videos designed to assist you with your PASCO equipment, technologies, and lab activities.



PASCO's Award-Winning Software

Choose from PASCO's award-winning software, including PASCO Capstone, SPARKvue, and Chemvue—FREE with your PASCO Portal license



PASCO Capstone™ is the ideal software for higher education and advanced physics investigations.



SPARKvue makes data collection, analysis, and sharing quick and easy for all sciences and grade levels.



Chemvue is a comprehensive platform for running and analyzing experiments in all chemistry disciplines.



Spectrometry software supports physics, chemistry, and biology lab topics like emission spectra, absorbance spectra, Beer's law, and kinetics experiments.



MatchGraph! software allows students to investigate beginner position and velocity concepts using motion sensors and Smart Carts.



Professional Development

New science teacher? No problem! With PASCO Portal, you are equipped to dive into hands-on science learning experiences with on-demand training & professional development. Learn the technology, get tips for instruction, and earn certificates. Explore PASCO Portal's professional resources designed to enhance your knowledge and hone your skills in applying PASCO's hands-on science and STEM solutions to your lab. These resources have been pre-recorded and are available on-demand for your convenience.



Online & Live Support

Get toll-free phone, email, and live chat support for PASCO Portal. Plus, easily search products and technical manuals all within PASCO Portal.

Order Information

Contact your PASCO Educational Consultant to purchase.

New Products

Wireless Hand Dynamometer

PS-3253

The Wireless Hand dynamometer combines a force load cell, 3 axis accelerometer, and gyrometer to analyze how grip strength changes through complex, swings, hits or jabs.

**NEW**

See page 55.

Wireless Thermocouple

PS-4256

**NEW**

The new Wireless Thermocouple extends the range of our temperature sensing line. Range from - 200 C to 1400 degrees C. Packaged with a type K thermocouple, students can follow solutions cooled with boiling liquid nitrogen, dry ice, or reached by commercial freezers.

See pages 59 and 225.

Smart Cart Fan Kit

ME-1254

**NEW**

What makes this fan so smart? It includes a rotating platform that can be used to demonstrate the vector nature of force. Raised markings on the base indicate the angle of the fan with respect to the path of the cart.

See page 113.

Wireless Absolute Pressure-Temperature Sensor

PS-4257

The Wireless Absolute Pressure-Temperature Sensor is built to work with the Ideal Gas Law Apparatus (TD-8596A), Absolute Zero Sphere (TD-8595), and Heat Engine Apparatus (TD-8572) to monitor pressure changes with increase or decrease of temperature.

See page 57.

**NEW****Wireless Voltage-Current Sensor**

PS-4254

The Wireless Voltage-Current Sensor is a smart alternative to a traditional multimeter. It can be used as a standalone unit by using the built-in display, or connected to a computing device to output measurements to PASCO software for graphical analysis.

See page 61.

**NEW****Smart Cart Friction Brake**

ME-1253

**NEW**

The Smart Cart Friction Brake is designed to bring a moving Smart Cart to a stop at any position on a dynamics track.

See page 114.

Meter Stick Mechanics Set

ME-7076 (without Sensors ME-7081)

NEW

Perform experiments in dynamics, projectile motion, and rotation with this meter-stick-based set.

This set combines the capabilities of three sets:

- Ball Ramp
- Meter Stick Rotation Set
- Meter Stick Torque Set

See page 103.



Meter Stick Rotation Set

ME-7074 (without Sensors ME-7078)

In the Meter Stick Rotation Set, a Half-Meter Stick rotates about any point desired. The Wireless Force Sensor can be attached to the rotating meter stick to directly measure the centripetal force on a mass attached to the Force Sensor with a string.

See page 105.

Meter Stick Rotation Components

ME-7072

These are the basic components of the Meter Stick Rotation Set (ME-7074). To use these components, you need a Half-Meter Stick, a Pivot, and a rod stand.



See page 105.

Ball Ramp Components

NEW

ME-7073

Add two meter sticks to these components to make a Ball Ramp (ME-7075). Two meter sticks form rails for a ball to roll on.



Ball Ramp

NEW

ME-7075

The Ball Ramp can be used as a projectile launcher and as an inclined plane. Two meter sticks form rails for a ball to roll on. The curved end of the Ball Ramp allows the ball to roll off the end of ramp horizontally. There is a level in the curved end so you can tell when the end is horizontal.

See page 102.



See page 103.

Ball Ramp End Stop

NEW

ME-7077



The ball ramp end stop catches the ball before it rolls off the end of the ramp. This end stop is made of foam and slides onto the Ball Ramp (ME-7075).

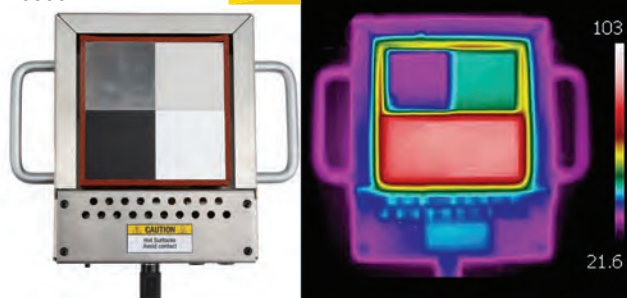
See page 103.

New Products

Leslie's Cube

TD-8350

NEW



The classic Leslie's Cube is updated to show all four surfaces together. The four surfaces (black, white, silver, shiny) have different thermal emissivities, causing them to radiate different amounts even though they are all at the same temperature.

See page 227.

Modular Circuits Generator

EM-3455

NEW

This versatile hand-crank generator allows students to generate electrical energy and learn what variables affect the output voltage.



See page 238.

Ferromagnetic Hysteresis

EX-5566

NEW

Study the hysteresis plot for a ferromagnetic core in a transformer.



See page 379.

Transformer Coils

- EM-8609 200 Turn
- EM-8610 400 Turn
- EM-8611 800 Turn
- EM-8612 1600 Turn
- EM-8613 3200 Turn

These high-quality coils are each labeled with the number of turns, the direction of the winding, and the maximum current. These coils are used in the Transformer Coils Set (EM-8615).



See page 257.

Primary/Secondary Coils

EM-6709

These nested primary and secondary coils have a removable soft iron core. Each coil has safety banana jacks.



Transformer Coils Set

EM-8615

These high-quality coils and laminated iron core provide an effective introduction to electromagnetic induction in transformers. Purchase them individually or as a complete set.

Transformer Core

EM-8614



This U-shaped iron core is designed to be used with two coils to form a transformer.

Diffraction Grating Set (10 pack)

OS-8443

This set of 10 diffraction gratings are mounted on stiff cardboard and have printed sample spectra.

See page 316.



AC/DC Smart Power Supply

PI-9525

The AC/DC Smart Power Supply is a Bluetooth Low Energy wireless signal generator. It outputs DC as well as sine, square, positive square, and triangle AC signals.

See page 275.



Current Balance

EM-8607

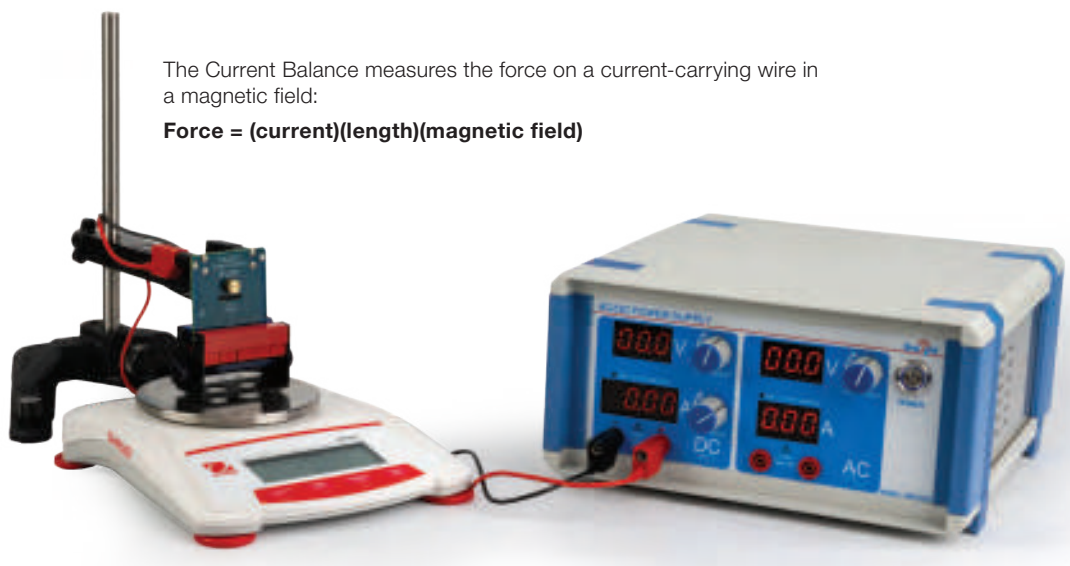
NEW

Magnetic Force on a Current-Carrying Wire Experiment

EX-5568

The Current Balance measures the force on a current-carrying wire in a magnetic field:

$$\text{Force} = (\text{current})(\text{length})(\text{magnetic field})$$



See pages 263 and 375.

AC/DC Power Supply

SE-9584

NEW

The AC/DC Power Supply has been designed specifically for use in teaching science. It can provide both direct current (DC) and alternating current (AC).



See page 271.

Kilovolt Power Supply

SE-9586

NEW

This Kilovolt Power Supply is used for electron tubes and electrostatics.



See page 273.

Make the switch to **PASCO** capstone™ 2

The Most Powerful Data Collection Software in Science Education

PASCO Capstone is a powerful and easy-to-use science program for collection and analysis of data from PASCO sensors. Data is collected and displayed in real time on a graph or your choice of display type. Use Capstone in the basic graph/table mode or choose to configure your own workspace with any of the many displays available.

Features

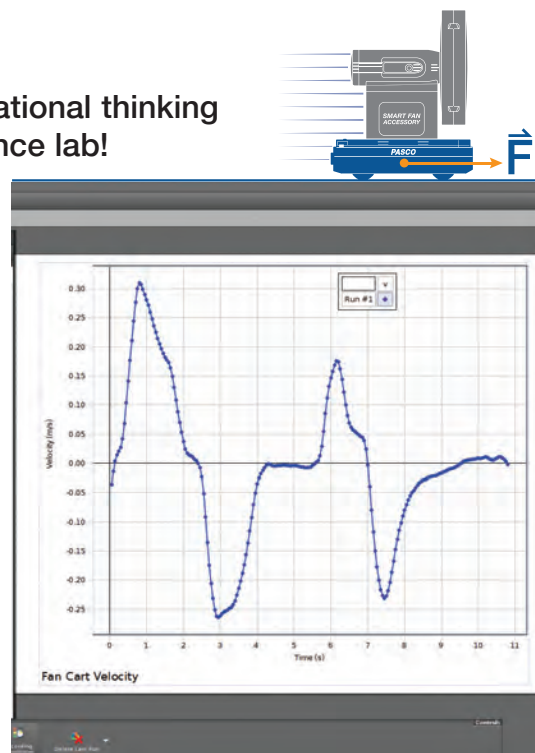
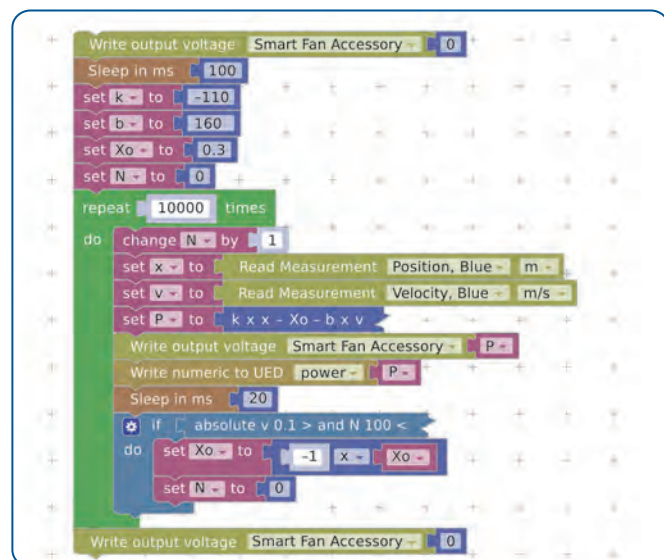
- ▶ Collect and display sensor data in real time.
- ▶ Choose from multiple display types: Graph, table, digits, oscilloscope, FFT, meter, bar meter, histogram, circuit emulator, video analysis, image, text box.
- ▶ Undo/redo gives you the freedom to explore without losing data.
- ▶ Sampling options: Periodically, or sample manually when you press a button.
- ▶ Graph user-entered data.
- ▶ Visual Statistics: Unique to Capstone is the ability to show minimum, maximum, and mean as lines on the graph and to show the standard deviation as a shaded area.
- ▶ Exclude or delete outlier data points from analysis.
- ▶ Apply curve fits ranging from linear to more complex fits such as damped sine, Gaussian, sine series, and user-defined fits.
- ▶ Add error bars to the graph. Choose from percent error, fixed error, or point-by-point error defined by a data set.
- ▶ Draw predictions on the graph to compare to future data runs.
- ▶ Quick-Calcs on the graph axes allow you to linearize the data plot.
- ▶ Create data models using the Calculator to compare to data runs on a graph.
- ▶ Synchronize videos of the phenomenon with the corresponding sensor data and replay it to see the relationship between the motion and the graph.
- ▶ Use Blockly coding in Capstone to program sensors and controllers to sense the environment around you and control a wide variety of things like motors, lights, and fans.
- ▶ Video Analysis: Record a movie, track a moving object, and convert the motion into data on a graph. Show velocity vectors on the moving object.
- ▶ Updated regularly: PASCO Capstone is updated regularly, supporting new hardware, fixing issues, and adding new features. The latest new features are Blockly-based coding, graph pop-up tools, and circuit emulation.

See the next three pages for more details.

Blockly **Block-based Coding**

- ▶ Control all PASCO sensors and interfaces
- ▶ Create sense and control programs
- ▶ Control outputs from sensor inputs

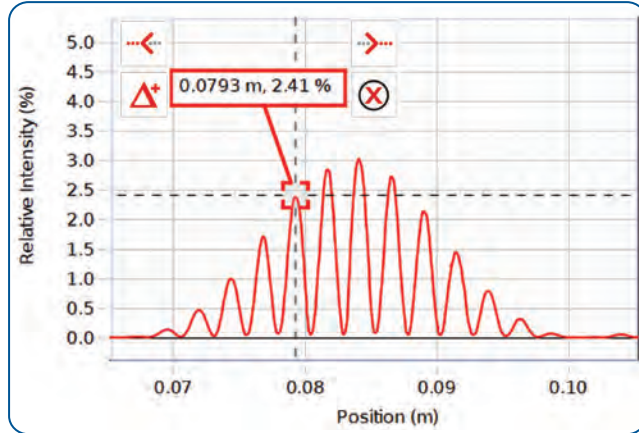
Bring computational thinking
into your science lab!



Graph Pop-up Tools

Visit pasco.com/capstone for more information.

Quick access to commonly used analysis tools

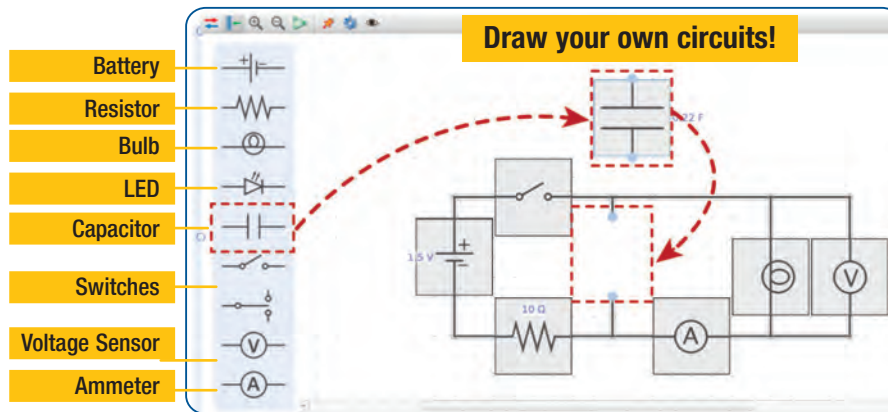


Capstone has all the software tools you need for data collection and analysis. And we continue to add more features, based on input from physics educators just like you!

- ▶ Exclude or delete selected data points from analysis.
- ▶ Create models using the calculator.
- ▶ Calculated columns in tables
- ▶ Error bars
- ▶ Weighted linear fit that takes into account error bars
- ▶ More complex curve fits such as damped sine, Gaussian, sine series, and user-entered fits
- ▶ Smooth data directly on a graph with slider tool.
- ▶ Global preferences settings

Circuits Emulation

Reinforce circuit concepts and tackle student misconceptions using circuit visualization.



Combine real-world circuits with simulations, animations, and live measurements.

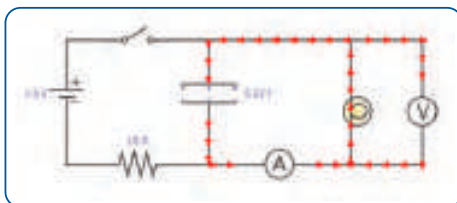
With this tool you can:

- ▶ Construct and modify circuits
- ▶ Show conventional current and electron flow animations
- ▶ Animate circuits with live sensor data

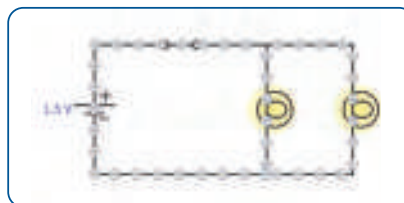
Build your own circuits in Capstone. Drag and drop components and draw wires to connect them.

- ▶ Demonstrate series and parallel
- ▶ Charge and discharge capacitors

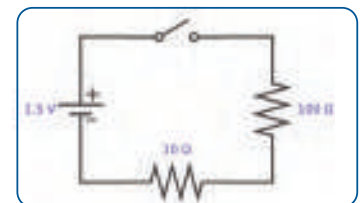
Examples of other circuit emulations:



- ▶ Animate conventional current flow
- ▶ Animate a capacitor — charge or discharge
- ▶ Edit capacitor values



- ▶ Animate electron flow
- ▶ Connect components in parallel or series



- ▶ Operate switches
- ▶ Edit voltage and resistor values

Spread the word!

PASCO Capstone™ is now available as an app for Windows® and macOS! Students can purchase a 1-year personal license with no auto-renewal. Search for "PASCO Capstone" in your preferred app store.

Download a free 30-day trial at www.pasco.com/capstone

macOS or Windows®

Order Information

PASCO Capstone Site LicenseUI-5400
 PASCO Capstone Student License
 (APP Store/Microsoft Store)

TOOLS

**Configure PASCO Hardware**

Works with PASPORT, ScienceWorkshop, and Wireless Sensors

**Photogate Timer Wizard**

Easily configure photogates and timing measurements

**Data Summary**

- Equations/calculations
- Fundamental constants
- Experimental constants
- Trials and runs

**Sensor Calibration Wizard**

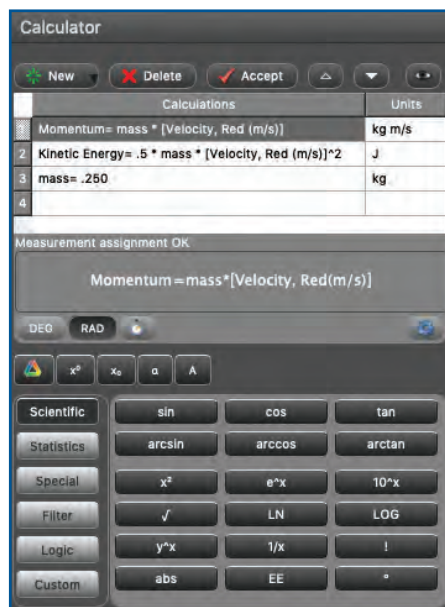
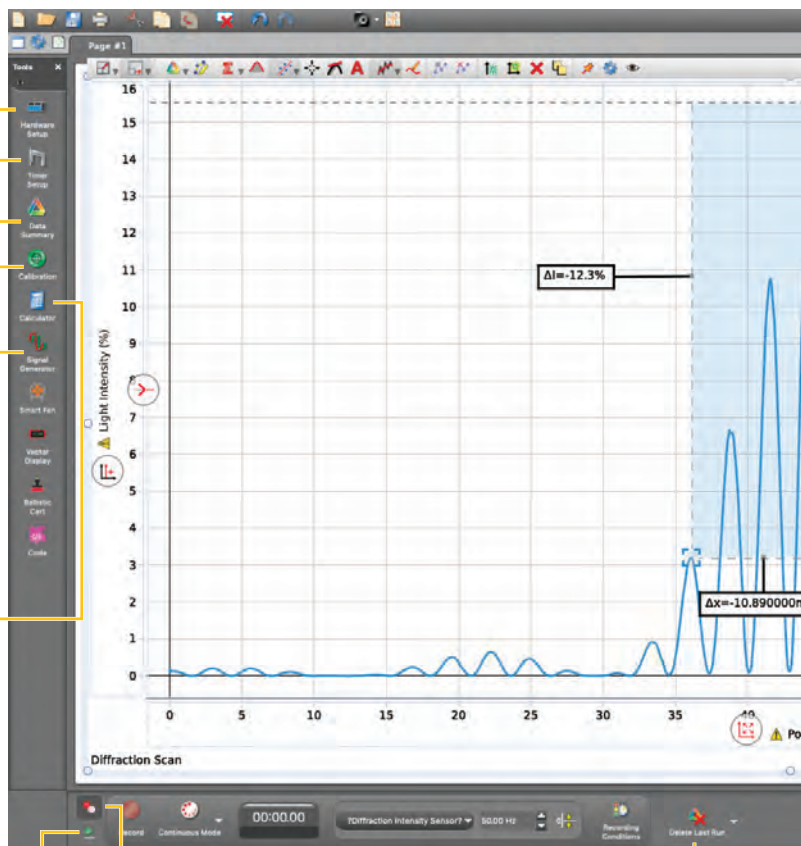
- Step by step calibration
- Many calibration types

**Signal Generator**

- Scan through a range of frequencies
- Control signal output with a calculation

**Calculator**

- Graph modeling
- Create data sets using sensor data



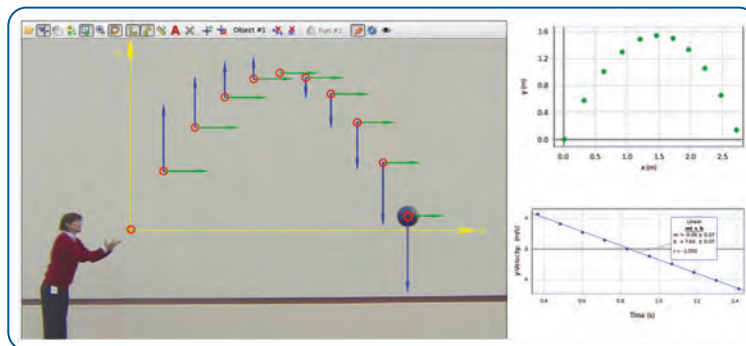
Sophisticated scientific calculator has statistics, calculus, filters, logic functions, and special operations such as amplitude and period.

**Replay Your Data**

- Change replay rate
- Increment by frame
- Loop playback

**Sampling Options**

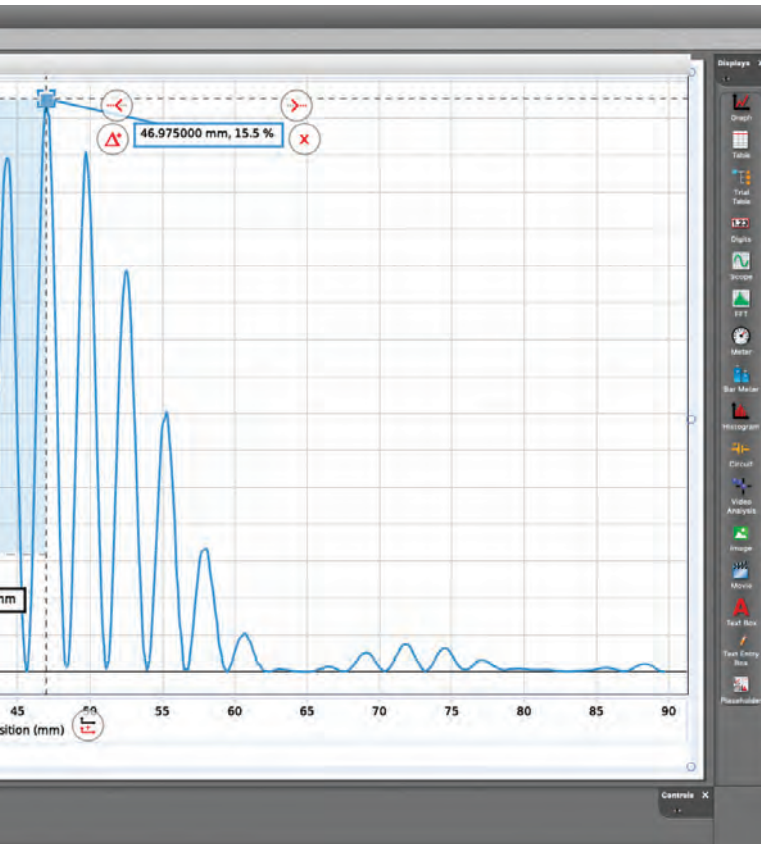
- Continuous manual sampling
- Fast monitor mode
- Independent sensor sampling rates
- Start/stop conditions
- Zero sensor

Capstone 2 Includes Video Analysis

Import video and analyze the motion of objects to measure position, velocity, and acceleration. With this tool you can also:

- Show velocity and acceleration vectors
- Use magnifier to identify exact center of an object
- Use calibration ruler at any time
- And so much more!

PASCO's
proximity in-app
sensor pairing:
U.S. Patent
Number
10,356,594



Delete Runs

- ▶ Last run only
- ▶ Select from list
- ▶ All runs

Made a mistake?

Just hit



DISPLAYS

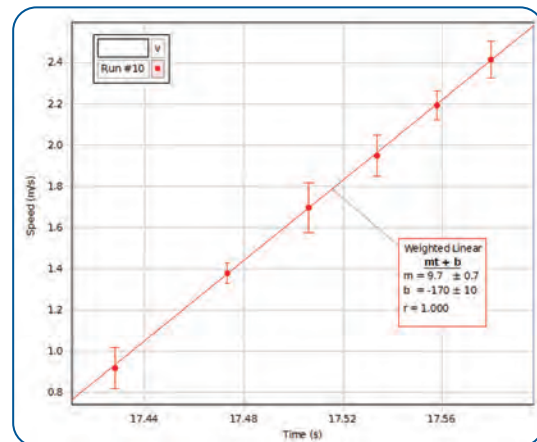
Display Your Data Your Way

▶ Graph ▶ Table ▶ Digits ▶ Scope ▶ FFT ▶ Meters

Graph Tools Include

- ▶ Draw predictions on graphs before taking data.
- ▶ Multiple y-axes and/or multiple plot areas
- ▶ Perform Quick-Calcs on the graph axis to linearize data.
- ▶ Curve-fits report the uncertainties in the parameters.
- ▶ Multi-coordinate tool gives y-values wherever it intersects data.

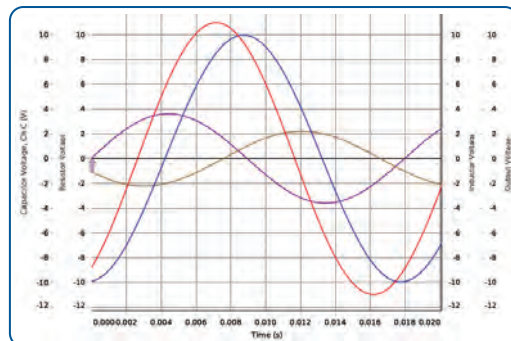
Error Bars and Weighted Linear Fits



Graph uncertainties using user-entered error bars, absolute error, or percent error. The weighted linear fit incorporates the error bars.

Visit pasco.com/capstone for more information.

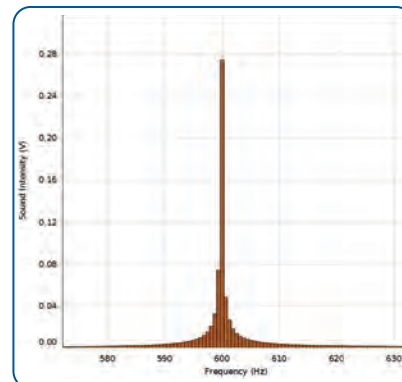
Oscilloscope Display



This display behaves like an authentic digital oscilloscope.

- ▶ Trigger
- ▶ Single trace collection
- ▶ Sample rate tied to time axis scale
- ▶ Set trace offset

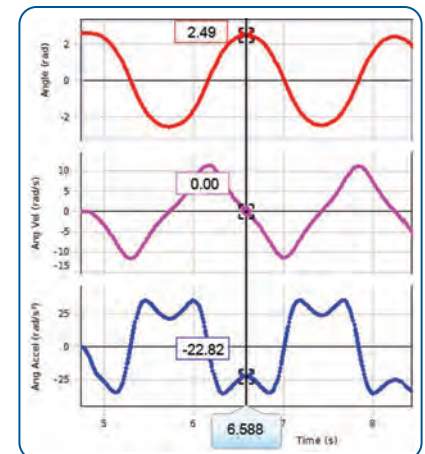
FFT



Display data in the frequency domain to find peak frequency and harmonics.

- ▶ Sample rate tied to axis scale
- ▶ Normalize data
- ▶ Adjust BIN width

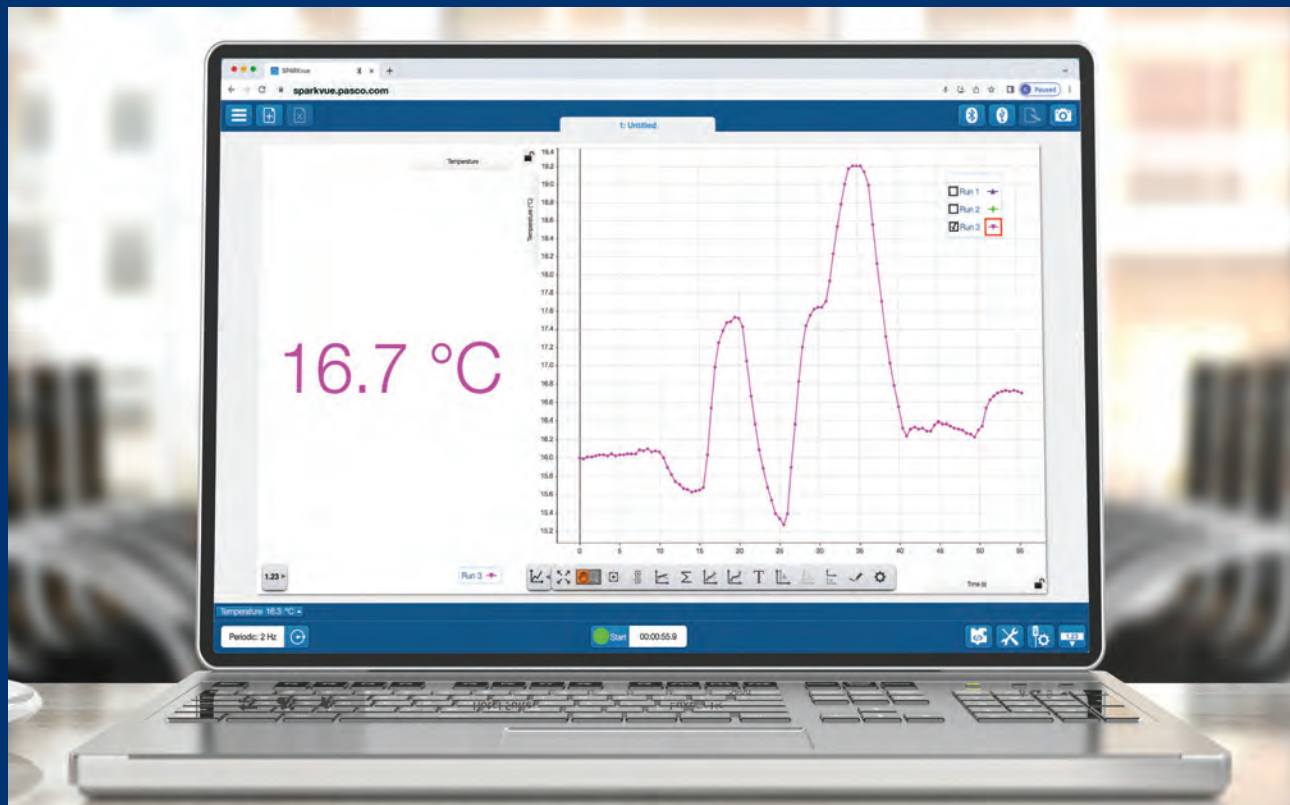
Multi-Coordinate Tool



Easily show the relationship between multiple data plots by comparing data values across the time axis.



Award-winning data collection and analysis software for any platform



SPARKvue is uniquely designed to deliver the features educators love within a framework students can easily use. It provides a powerful, all-in-one platform with intuitive tools for data collection, visualization and analysis, as well as features for block coding and collaboration. This all-in-one approach simplifies lab setups and data collection for science courses, while also equipping after-school programs with the tools they need to code, create, and explore. Visit us online to try it for free and see how SPARKvue can help you spark a lifelong love of science learning.

Designed for All Sciences

Collect data in real time using PASPORT or Wireless Sensors.



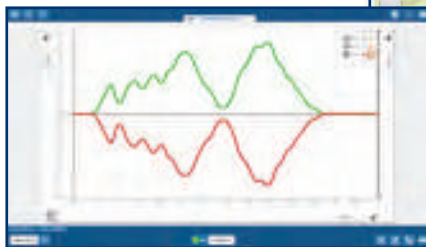
SPARKvue comes installed on every SPARK LXi2 and SPARK LX AIR.



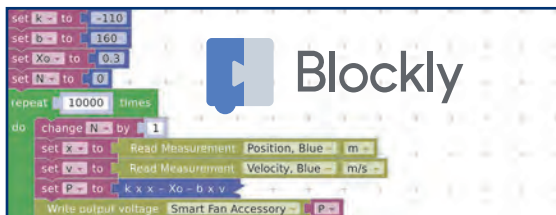
SPARKvue includes interactive data displays that are specific to your activity.



PASCO's proximity in-app sensor pairing:
U.S. Patent Number 10,356,594



Data Collection:



- **Live Data Bar:** See sensor readings before recording
- **Periodic Sampling:** Automatic sampling at a fixed rate
- **Manual Sampling:** Saves data only when a user specifies
- **Blockly:** Use code to control sensor and interface data collection
- **Collaborate:** Start a shared session and stream results in real time

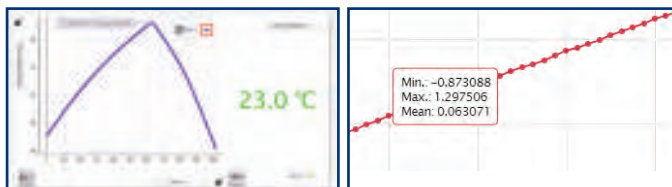
Data Displays:

- Graph displays with multiple plot areas and axes
- Digits
- Meter
- Data tables
- FFT
- Map Display
- Weather Dashboard
- Oscilloscope

Cross-Platform Compatibility

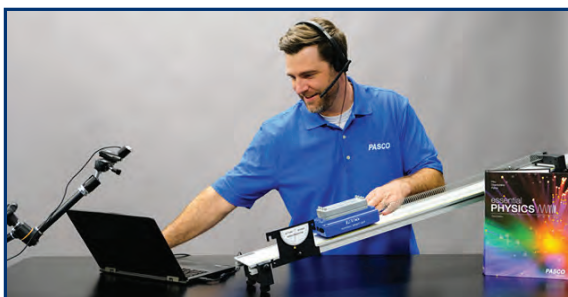


Tools for Data Analysis:



- **Scale-to-Fit:** Adjust axis for optimal data view
- **Data Selection:** Easily select a portion of data for analysis
- **Prediction Tool:** Visualize a prediction alongside the data
- **Smart Tool:** Find data coordinates and calculate delta values
- **Calculation Tools for Statistics:** Easily obtain statistics such as minimum, maximum, mean values and more
- **Slope Tool:** Find the slope of a point
- **Curve Fits:** Various curve fits with goodness of fit values
- **User Annotation:** Easily add text notes to runs or points
- **Axes:** Add another y-axis or a new plot with one button

SPARKvue Resources:



- Video Library: 330+ free videos featuring SPARKvue
- PASCO Blog: Dozens of fun applications for SPARKvue
- Experiment Library: 80+ free and downloadable SPARKvue labs
- FREE webinar training from PASCO professionals on our website
- Summer Institutes: Software and technology training
- Visit pasco.com/training-and-development for more information.

This **FREE** award-winning software now runs in your browser!

The award-winning SPARKvue software is compatible with ALL your devices! SPARKvue comes pre-installed on most PASCO dataloggers. Use the free Google Play native application for your Android smartphones and tablets. Use the free App Store native application for your iOS and iPadOS devices. Use the free browser-based Progressive Web Application (PWA) for Chromebook™, laptops, and desktop computers with Google Chrome and Microsoft Edge browsers. Go to sparkvue.pasco.com to access the PWA.

Looking for secure software downloads for your institution? See pasco.com/sparkvue to purchase PASCO Portal or site licenses.

SPARKvue®

Launch now as
a Web App

PWA +



Looking for additional options? See pasco.com/sparkvue for more details.

MatchGraph!™ Software

PASCO MatchGraph! **FREE**

- ▶ Students feel the motion firsthand and learn how to interpret motion graphs! Watch your students compete to get the best match score.
- ▶ The sample graphs to match include both Position vs. Time and Velocity vs. Time.
- ▶ The student moves back and forth in front of a motion sensor in an attempt to match the motion represented on the graph.

High Score

Name Score

Lewis	90.78
Ann	90.46
James	75.47
Brett	70.24

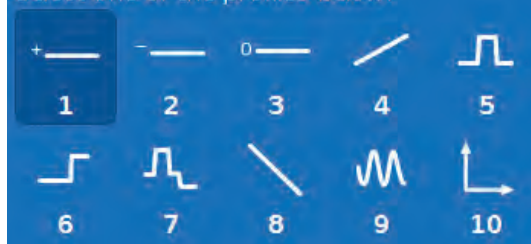
Students learn while having fun competing for the highest score. The program keeps track of the scores for each profile.

Select one of the profiles below:

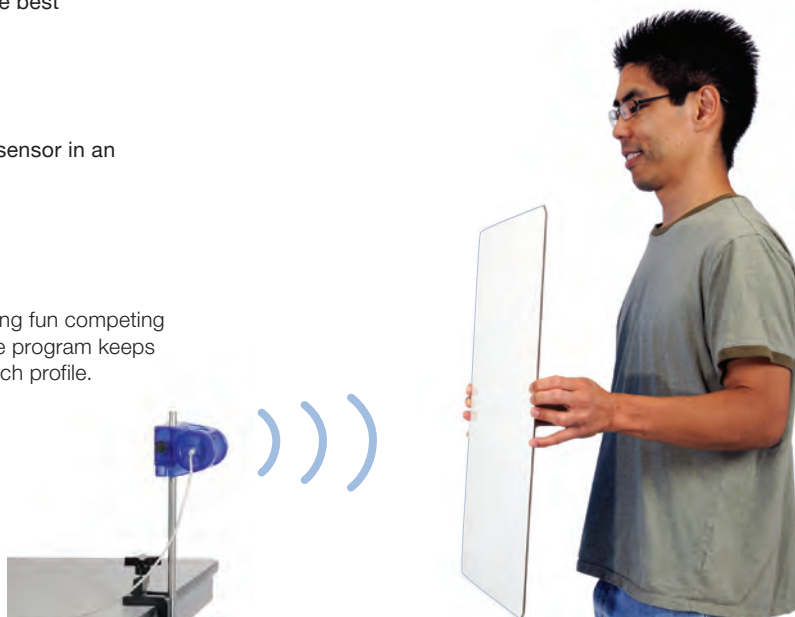


There are nine position profiles to match. The tenth choice allows students to use the motion sensor without a profile on the graph.

Select one of the profiles below:



The velocity profiles to match correspond to the position profiles.



The students get to see their motion for a few seconds before the matching starts so they can get lined up. Here the black line is the match profile and the red line is the student's attempt to match it.

FREE MatchGraph!™ Software

Go to **pasco.com/downloads** and click on MatchGraph.

Download FREE MatchGraph! software for Mac® and Windows® computers at **pasco.com**. Download the free iPad® or Android™ app on the App Store or Google Play.



Now works
with all
Motion
Sensors and
Smart Carts!

Order Information

Required:		
Wireless Motion Sensor	PS-3219	p. 53
OR		
PASPORT Motion Sensor	PS-2103A	p. 34
OR		
Motion Sensor II	CI-6742A	p. 26
*Requires a USB or Bluetooth interface.		
OR		
Smart Cart (Red)	ME-1240	p. 52
OR		
Smart Cart (Blue)	ME-1241	p. 52

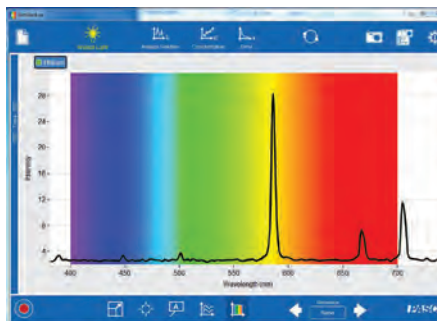
PASCO's **FREE** Spectrometry Software Puts Learning First

Our award-winning Spectrometry Software works on iOS®, Android™, Computers, and Chromebooks*

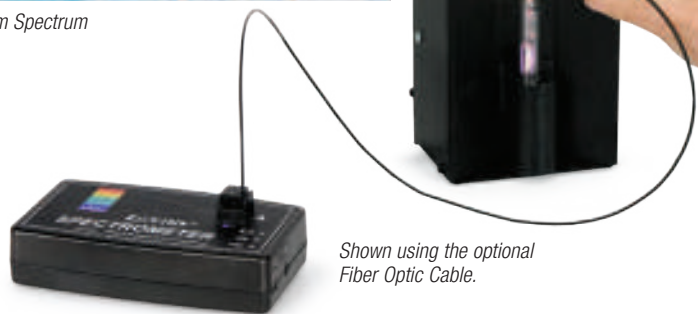
- ▶ Designed by teachers
- ▶ Specialized software specifically targets spectrometry activities
- ▶ Program guides students through the four common types of spectrometer uses
- ▶ Calibration routine is made obvious

The four specially targeted activities are:

1. Analyze light sources with the optional Fiber Optic Cable.
2. Analyze the absorbance, transmittance, and fluorescence of colored solutions.
3. After the analysis wavelength is set, you can easily create calibration curves and determine the unknown concentration of a solution.
4. Observe the kinetics of a reaction involving a colored solution. Easily create the required graphs ($\ln(x)$, $1/x$) to determine the order of the reactants.



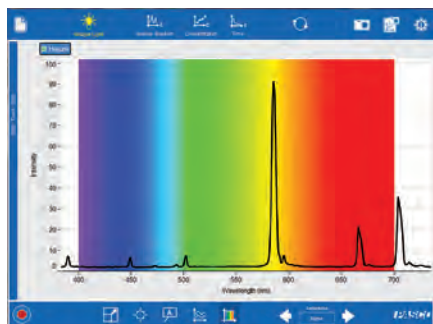
Helium Spectrum



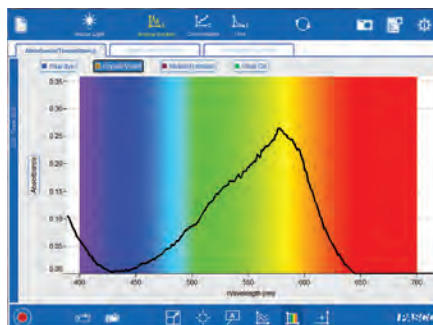
Shown using the optional Fiber Optic Cable.

The Wireless Spectrometer comes with **PASCO's award-winning Spectrometry software.**

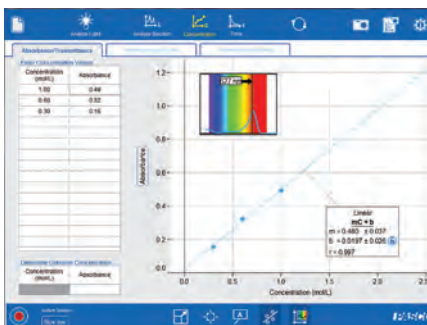
- ▶ Free software for iOS®, Android™, Windows®, and Mac®
- ▶ Available for Chromebooks™ with Google Play
- ▶ Designed specifically for introductory spectrometry experiments



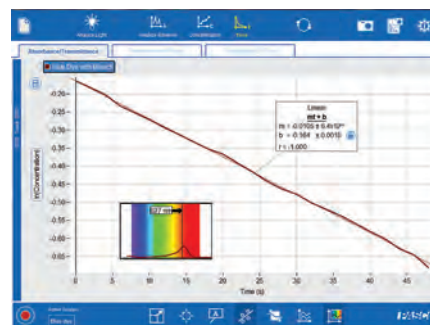
1. Analyze light sources with the optional Fiber Optic Cable.



2. Visualize absorbance across the full visible spectrum.



3. Create Beer's Law plots to relate absorbance and concentration.



4. Quickly plot calculations of concentration vs. time to determine the order of the reaction.

Works with PASCO's Wireless and UV-Vis Spectrometers.



PS-2600A Includes:

- PASCO Spectrometer
- Cuvettes (10)
- Spectrometry Software



SE-3607 Includes:

- Semi-Micro Volume Cuvettes (qty. 10)
- Cuvette Rack
- USB-A to USB-B Cable
- External AC Adapter, 24 V Power Supply
- Foam Lined Carrying Case (ABS)

*See list of supported Chromebooks at pasco.com/spectrometry

Order Information

Wireless Spectrometer (VIS).....	PS-2600A
OR	
UV-Vis Spectrometer.....	SE-3607
Required for External Light Sources:	
Fiber Optics Cable.....	PS-2601 p. 310

Measuring with Sensors

In Physics and Engineering, we measure everything in every way we can. Sensors make it possible to perform measurements that cannot be obtained any other way.

At PASCO, we offer two types of sensors: Sensors that require an interface (PASPORT and ScienceWorkshop) and sensors that connect Bluetooth (Wireless). These sensors can be implemented individually or simultaneously depending on your class devices and learning goals.

Which platform do you use?

1. Mac® and/or Windows® Desktop Computers or Laptops

Recommendation:

- **PASCO Capstone Software** (see pages 8-11): This data collection and analysis software is the preferred choice of physics and engineering teachers.
- **550 or 850 Universal Interface:** Choose the 550 if you are teaching high school physics (unless you are one of those high school teachers who has to have the most powerful tools). Choose the 850 if you are teaching college physics or engineering.



850 Universal Interface
UI-5000 (see page 20)



550 Universal Interface
UI-5001 (see page 23)



Wireless Force
Acceleration Sensor
PS-3202 (see page 55)



PASPORT
High Resolution
Force Sensor
PS-2189 (see page 36)

2. Tablets (iPad® or Android™), Smartphones and/or Chromebook™

Recommendation:

- **SPARKvue Software** (see page 12-13): SPARKvue is data collection software for tablets, smartphones, and Chromebooks. While PASCO Capstone is very powerful, it is only available for Mac® and Windows®.
- **Wireless Sensors and Wireless AirLink Interface:** Use Wireless Sensors because tablets may not have a USB port. Whenever a Wireless Sensor is not available, use the AirLink with a PASPORT sensor.



Wireless Force
Acceleration Sensor
PS-3202 (see page 55)



AirLink®
PS-3200 (see page 50)

3. Need a Standalone Datalogger? SPARK LXi2 & LXAIR DATALOGGERS

Recommendation:

- **SPARK LXi2:** This all-in-one datalogging solution works for classrooms without computers or for outdoor use. The SPARK LXi2 can be used with wired PASPORT sensors as well as PASCO's Wireless Sensors. It is battery-powered, has a large color touchscreen, and is loaded with PASCO SPARKvue, MatchGraph, and Spectrometry software.



SPARK LXi2
PS-3600B
(see page 48)

- **SPARK LX Air:** is PASCO's slimmed down all-in-one device for data logging, data display, and data analysis. Designed for a wet-lab environment, the LX Air is portable, durable, and splash-proof. The LX Air can connect to up to 5 Wireless Sensors at once. It is also compatible with the SPARKlink® Air and the 550 Universal Interface.



SPARK LX Air
PS-3620
(see page 49)

New to sensors? Have sensors already?

1. New to Sensors?

- **PASCO Capstone Software** (see pages 8-11): Unless you are using tablets, smartphones, or Chromebook™, we recommend using PASCO Capstone for physics and engineering labs.
- **550 Universal Interface:** The 550 Universal Interface is perfect for beginning data acquisition. It has multiple sensor ports to accommodate experiments that require more than one sensor (as most experiments do). It also has a signal generator and powered output for electronics and speakers.
- **PASPORT Sensors:** Many of these sensors have multiple sensor elements in one sensor, such as the Absolute Pressure/Temperature Sensor (page 39).
- **Wireless Sensors** (see pages 51-69): These sensors connect via Bluetooth® to devices running either PASCO Capstone or SPARKvue Software. They offer an affordable solution for courses without interfaces.



550 Universal Interface
UI-5001 (see page 23)

Wireless Force
Acceleration Sensor
PS-3202 (see page 55)



Wireless Smart Cart
ME-1240 (see page 52)

2. Have ScienceWorkshop Analog Sensors?

- **PASCO Capstone Software** (see pages 8-11): Unless you are using tablets, smartphones or Chromebook™, we recommend using PASCO Capstone for physics and engineering labs.
- **850 Universal Interface:** The 850 Universal Interface is our most versatile and powerful instrument. It has twice as many sensor ports as the 550 for those more demanding experiments. It also has three signal generators, a high-power output (15 V at 1 A) for speakers and heating elements, and two high-frequency outputs (DC to 500 kHz) for electronics.
- **Use Your Existing ScienceWorkshop Sensors** and add any PASPORT sensors you need. You may want to use the PASPORT 2-Axis Force Platform (page 37) or the Absolute Pressure/Temperature Sensor (page 39).



850 Universal Interface
UI-5000 (see page 20)

3. Have PASPORT Sensors?

- **PASCO Capstone Software** (see pages 8-11): Unless you are using tablets, smartphones, or Chromebook™, we recommend using PASCO Capstone for physics and engineering labs.
- **550 or 850 Universal Interface:** Choose the 550 if you are teaching high school physics (unless you are one of those high school teachers who has to have the most powerful tools). Choose the 850 if you are teaching college physics or engineering.
- **Use Your Existing PASPORT Sensors** (see pages 31-47) and add the UI-5100 Voltage Sensor (page 29) for high speed sampling of circuits and the UI-5101 Sound Sensor (page 28) to detect sound waves.
- **SPARK LXi2:** Choose the SPARK LXi2 if you want to use your PASPORT sensors without computers, or if you need to collect data outside.



550 Universal Interface
UI-5001 (see page 23)



SPARK LXi2
PS-3600B (see pages 48)

Interfaces

Use an interface to connect sensors to devices running PASCO software.

AirLink®

PS-3200

The AirLink is the most cost-effective way to wirelessly connect PASPORT sensors.



Connect one PASPORT sensor via Bluetooth® or through a USB connection. USB cable included.

Order Information

AirLink Interface PS-3200

SPARK LXi2

PS-3600B



Collect data from PASPORT and Wireless Sensors with the SPARK LXi2. Includes two ports for PASPORT sensors, five virtual ports for Wireless Sensors, and two ports for use with the included Fast Response Temp Probe and the Voltage Probe.

Scan to learn more:



pasco.com/lxi2

Order Information

SPARK LXi2 Datalogger PS-3600B

SPARK LX Air

PS-3620



The SPARK LX Air Datalogger is PASCO's slimmed down all-in-one device for data logging, data display, and data analysis. Don't risk damaging your school computer during hands-on experiments! With the LX Air, you are in control of the technology in your classroom. Designed for a wet-lab environment, the LX Air is portable, durable, and splash-proof.

Order Information

SPARK LX Air Datalogger PS-3620

550 Universal Interface

UI-5001



The 550 Universal Interface is fast, flexible, and powerful while staying affordable. The 550 has half the ports and many of the great features of our 850 Universal Interface in a smaller package, with Bluetooth® and USB connectivity.

Order Information

550 Universal Interface UI-5001

850 Universal Interface

UI-5000



The 850 Universal Interface is the most powerful science education lab interface in the world. It has the most ports, the highest sampling rates, and the most powerful functionality. It can also replace several pieces of lab instrumentation, saving both lab space and budget dollars.

Order Information

850 Universal Interface UI-5000

Interface Comparison

Compare the features and capabilities and see which interface works best in your lab.



	AirLink PS-3200	SPARK LXi2 PS-3600B	SPARK LX Air PS-3620	550 Universal Interface UI-5001	850 Universal Interface UI-5000
PASPORT Ports	1	2	0	2	4
Built-in Temp and Voltage	No	Yes	No	No	No
Analog Inputs	0	0	0	2 (± 10 V, optional gain voltage 10x, 100x)	4 (± 20 V, optional gain voltage 10x, 100x, 1000x)
Digital Inputs	0	0	0	2	4
Connects via USB	Yes	Yes	Yes	Yes	Yes
Connects via Bluetooth	Yes	Yes	Yes	Yes	No
Rechargeable battery for cordless operation	Yes	Yes	Yes	No (AC adapter only)	No (AC adapter only)
Works with PASCO Capstone Software	Yes	No	No	Yes	Yes
Works with SPARKvue Software	Yes	Yes	Yes	Yes	No
Accepts PASPORT Sensors	Yes	Yes	No	Yes	Yes
Accepts ScienceWorkshop Sensors	No*	No*	No*	Yes	Yes
Maximum Sampling Rate	Sensor-dependent <1000 Hz	Sensor-dependent <100 kHz	Sensor-dependent <100 kHz	Up to 2 MHz on one channel	10 MHz on two channels simultaneously
Signal Generator	N/A	N/A	N/A	± 8 V, at 400 mA, DC to 100 kHz	#1 ± 15 V at 1 A, DC to 100 kHz #2 & #3 ± 10 V at 50 mA DC to 500 kHz, independent
Included Items	USB Cable	AC adapter, fast response temperature probe, voltage probe	USB cable, USB wall charger	USB cable, power supply	USB cable, power supply
Expansion Port	No	No	No	No	44-pin port with voltage outputs, analog inputs, and digital I/O channels

* The AirLink, SPARKlink Air, SPARK LXi2, and SPARK LX Air can accept most ScienceWorkshop sensors with the proper adapter (see page 50), although they won't have the same high maximum sample rates. One exception is the Sound Sensor (UI-5101), which is not recommended for use with an adapter.

The PASCO 850 Universal Interface:

The Ultimate Sensor Interface for Physics and Engineering

When used with PASCO Capstone, the 850 Universal Interface has the same functionality as several lab devices combined, all while taking up less than half the bench space.

An incredible value!



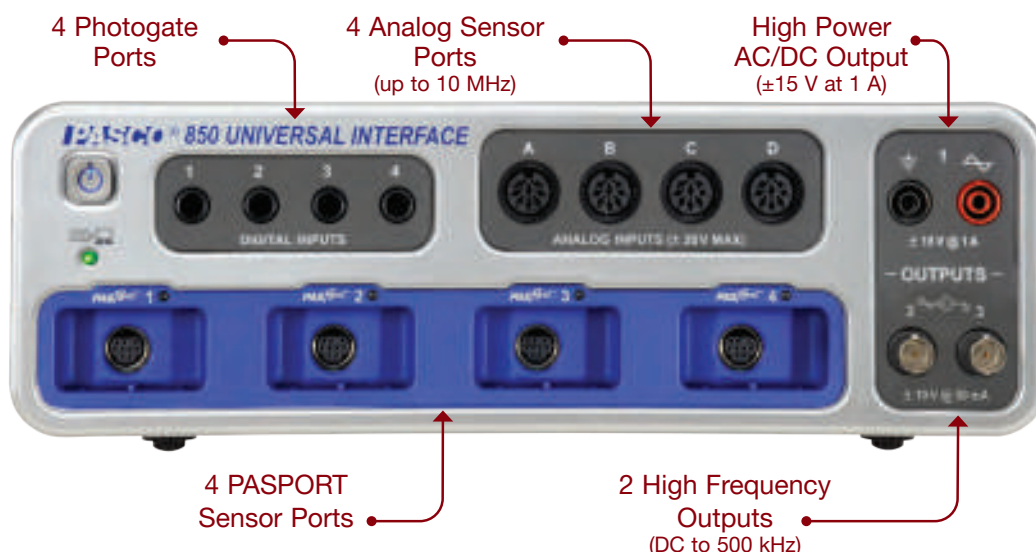
850 Universal Interface



PASCO Capstone Software



DC Power Supply, Oscilloscope, Digital Multimeter, and Function Generator



- **Study AC Circuits:** 10 MHz sample rate on two analog channels simultaneously; two independent high frequency outputs (50 mA at 10 V; DC to 500 kHz)
- **Power Speakers and String Vibrators:** High power function generator (1 A at 15 V; DC to 100 kHz)
- **Use Any Sensors You Have:** Collect data with ScienceWorkshop and PASPORT sensors, individually or simultaneously at the same time
- **Explore Modulation:** External trigger input/output for synchronizing multiple 850s
- **Do 87 Core Physics Experiments:** Check out the Comprehensive 850 Physics Lab Manual (UI-5813; see page 71). Download online at pasco.com/comprehensivephysics
- **For detailed specifications:** www.pasco.com/850

Order Information

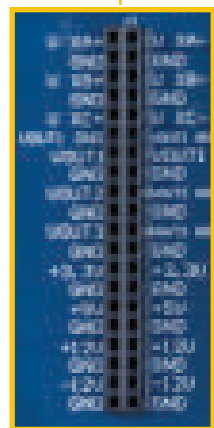
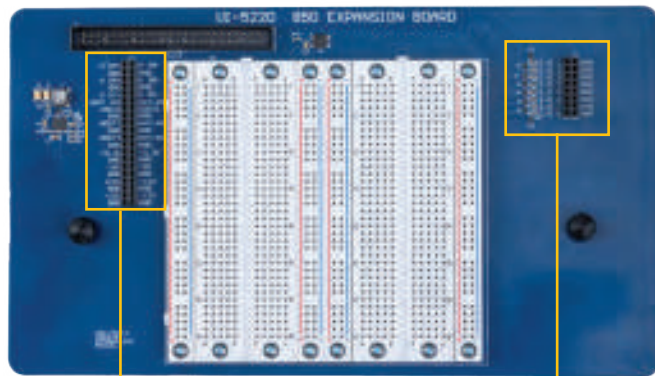
850 Universal Interface.....	UI-5000
Required:	
PASCO Capstone Software.....	pp. 8-11
Recommended:	
BNC Function Generator Output Cable.....	p. 22
Replacement Part:	
850 Universal Interface Replacement Power Supply.....	UI-5200

850 Expansion Board

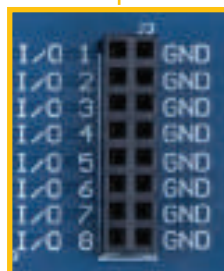
UI-5220

The 850 Expansion Board plugs into the Expansion Port on the back of the 850 Universal Interface. It is a break-out of all the connections available through the back port including eight digital input/output ports, three voltage inputs, three DC power supplies (3.3 V, 5 V, ± 12 V), and access to the three front signal generators. The Expansion Board also includes a circuit breadboard that students can build their own circuits on. In addition, students can do sense and control experiments using Blockly in Capstone to control this board.

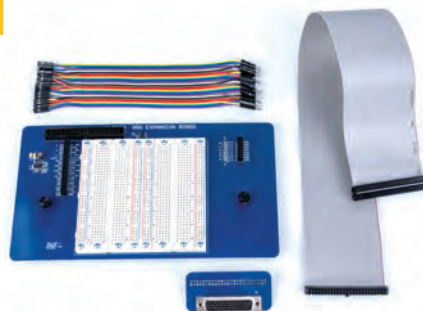
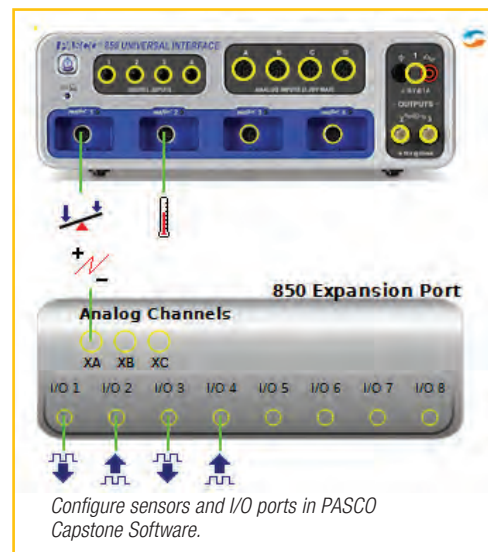
Any sensors that plug into the front of the 850 Universal Interface can be used simultaneously with the sensors that are available through the back Expansion Port of the 850.



3 Voltage Sensors
3 Signal Generators
+ 3.3 V DC Voltage
+ 5 V DC Voltage
 ± 12 V DC Voltage



8 Digital I/O



Includes:

- Expansion Board with breadboard and 2 thumbscrews
- Connector Board
- Ribbon Cable
- Male-to-Male Jumper Wires (15 cm long) (40)

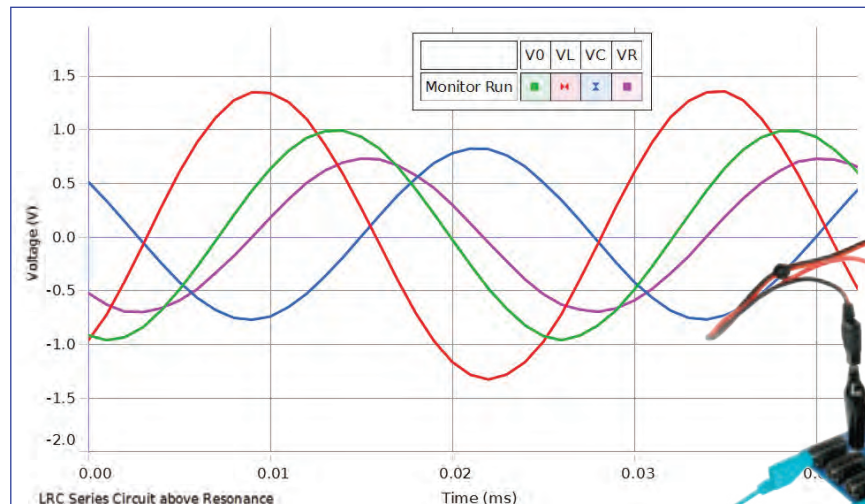
Features:

- ▶ **Signal Generator 1:** 15 V, 1 A, Maximum Frequency 100 kHz
- ▶ **Signal Generator 2:** 10 V, 50 mA, Maximum Frequency 500 kHz
- ▶ **Signal Generator 3:** 10 V, 50 mA, Maximum Frequency 500 kHz
- ▶ **3 Analog Inputs** (± 10 V)
- ▶ **8 Digital Input/Outputs**
- ▶ **Fixed DC Voltage Outputs:** 3.3 V, 5 V, ± 12 V
- ▶ **Circuit Breadboard**
- ▶ **Auto-identification** in PASCO Capstone
- ▶ **Expansion Board** connects the 850 using screws into the inserts on top of the 850 Interface.
- ▶ **Expansion Board** can be used on top of the 850 or on table-top beside the 850.

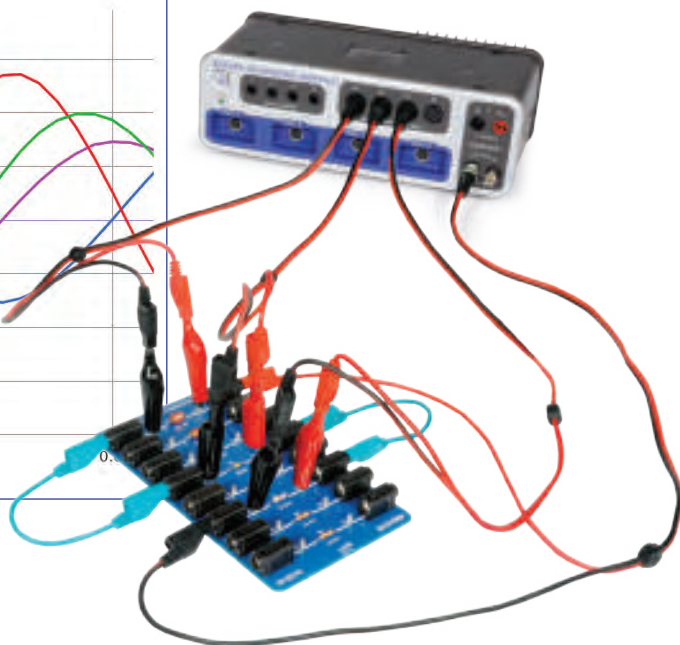
Order Information

850 Expansion Board.....	UI-5220
Required:	
850 Universal Interface	UI-5000
PASCO Capstone Software	pp. 8-11
Recommended:	
Resistor Pack.....	EM-8784
Capacitor Pack.....	EM-8785
Electronic Components – AC/DC Lab.....	EM-8668

850 Universal Interface Accessories



Four Channel Oscilloscope in PASCO Capstone



Dual Independent High Frequency Function Generators

Independent control of frequency, waveform, and amplitude. The voltages across the source, inductor, capacitor, and resistor are displayed in the oscilloscope.

BNC Function Generator Output Cable

UI-5119 (unshrouded) UI-5129 (shrouded)

- Converts the BNC output to two banana cords for the 850's function generators #2 and #3.



Shown in use with the 850 Universal Interface.

Order Information

BNC Function Generator Output Cable (unshrouded) UI-5119
BNC Function Generator Output Cable (shrouded) UI-5129

Resistor Capacitor Inductor Network

UI-5210

Board components can be used to investigate Kirchhoff's Circuit Laws, Ohm's Law, RC circuits, and AC. LRC circuit theory with resonant frequencies between 55 kHz and 135 kHz, depending on values used.



Includes

- Two inductors: 6.8 mH, 2.5 mH
- Two capacitors: 3900 pF, 560 pF
- Four resistors: 47 k Ω , 3.3 k Ω , and two 1.0 k Ω .

Shown in use with the 850 Universal Interface.

Order Information

Resistor Capacitor Inductor Network UI-5210

8-Pin DIN Extension Cable

UI-5218

- Use to connect analog sensors to ports A through D on the 850.
- Analog sensors can also be plugged in directly to the 850 ports.



The 1.8 m long Extension Cable allows ScienceWorkshop Sensors to be used even further away from the interface. Multiple cables CAN be used in series. Also works with 750 and 500 interfaces.

Order Information

8-Pin DIN Extension Cable UI-5218

The PASCO 550 Universal Interface

This powerful interface for physics connects wirelessly or via USB.

This is the interface with the measurement capability for all types of physics experiments. It features:

- ▶ 2 MHz sampling rate
- ▶ 2 high-speed analog inputs
- ▶ 2 digital inputs for photogates and other timing sensors
- ▶ 2 PASCO PASPORT sensor inputs
- ▶ Signal generator with built-in Voltage and Current sensors

- ▶ Use with other PASPORT interfaces
- ▶ Connect to computers via USB
- ▶ Bluetooth® Low Energy

With the 550, your physics lab is equipped with high-speed data collection, signal generation, a power supply, oscilloscope and FFT displays, timers, and more.



550 Universal Interface Specifications:

2 High-speed Analog Inputs

Measurement Range: ± 10 V differential input
Input Impedance: 1 M Ω
Input Protection: ± 250 V continuous
Selectable Voltage Gain: X1, X10, X100
Resolution: 14-bit, 1.2 mV

2 Digital Inputs

Digital sensors such as Photogates and Time-of-Flight plug directly into the 550 Interface.

- ▶ Compatible with all ScienceWorkshop digital sensors
- ▶ Sensor Connect Detection
- ▶ 0-5 V TTL
- ▶ Bi-directional

2 PASPORT Inputs

Compatible with PASCO's complete line of more than 80 PASPORT Sensors.

- ▶ Sample rates depend on sensors

Signal Generator

Waveforms: sine, triangle, square wave, positive and negative ramps, DC

Frequency Range: 0.001 Hz to 100 kHz; 1 mHz resolution

Amplitude Range: ± 8 V

Resolution: 1.33 mV, 12-bit DAC.

Max Output Current: 400 mA at 8 V, over-current detection

Selectable Voltage Limit

Selectable DC Offset

Frequency Sweep Function

Measure Output Current, Voltage, Frequency, Peak Amplitude

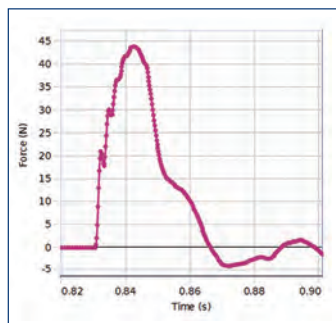
Order Information

550 Universal Interface	UI-5001
Required:	
PASCO Capstone Software	pp. 8-11
OR	
SPARKvue Software	pp. 12-13

Advantages of Using Analog Sensors with the 550 and 850 Universal Interfaces

The 550 and 850 Universal Interfaces are called “Universal” because they are capable of using ScienceWorkshop (analog) sensors as well as PASPORT sensors. Although the PASPORT sensors are the newer digital line of sensors, there are advantages to using the analog technology in the ScienceWorkshop sensors. Here are a few examples:

1. High Speed Collision with the Force Sensor (CI-6537)

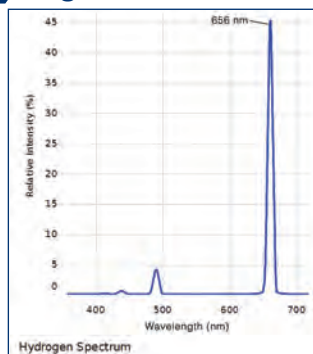


A cart colliding with a Force Sensor equipped with a clay bumper was recorded using a 5000 Hz sampling rate. Details of the clay's collapse can be seen in the data.



See page 26.

2. High Gain Detection of Violet Hydrogen Lines with the High Sensitivity Light Sensor (CI-6604)

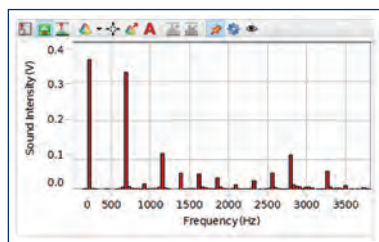


This Light Sensor has a high gain that, when combined with the interface gain, allows even the dimmest of the Balmer series to be detected.



See page 30.

3. High Resolution Sound FFT Spectrum of a Clarinet Note with the Sound Sensor (UI-5101)

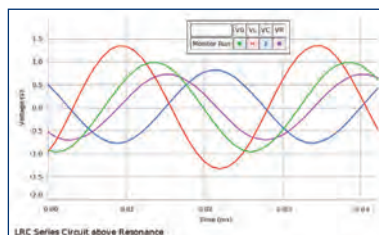


This FFT of a note being played on a clarinet was captured at a sample rate of 20 kHz. The waveform can also be seen on an oscilloscope in Capstone software.



See page 28.

4. High Synchrony LRC Circuit with the Voltage Sensor (UI-5100)



This oscilloscope display in PASCO Capstone shows the voltages across several components of an LRC circuit. The sample rates required for this can be as high as 10 MHz.

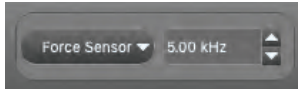


See page 29.

Students learn how various sensor settings and experimental setups affect the quality of their measurements.

1. Sampling Speed

Set the sampling rate high enough to capture the details of the phenomenon being measured.



2. Voltage Gain

Changing the gain of an analog sensor increases the resolution over a smaller voltage range.



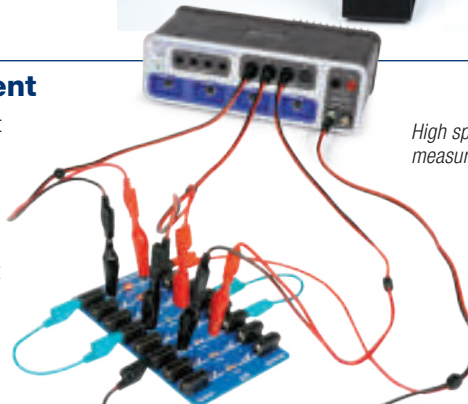
3. Voltage-Based Measurements

Analog sensing is based on voltage measurements. Understanding how devices convert physical changes like temperature, pressure, material deformation, and vibrations into voltage helps students understand the science behind their instrumentation.



4. Measurement Alignment

High speed voltage and current measurements in LRC circuits require that all measurements are synchronized on the same clock to ensure data integrity, and the accurate measurement of phase relationships.



High speed voltage and current measurements in LRC circuits.

Motion and Force

Motion Sensor II

CI-6742A

PASCO's digital ScienceWorkshop Motion Sensor II is used to measure position, velocity and acceleration. Ultrasonic pulse-ranging technology has a switch-selectable Standard Beam or Narrow Beam to reject false signals and produce cleaner data. The Motion Sensor sits firmly on a desktop or easily mounts to a rod stand or PASCO Dynamics Track.



Connector:

Dual stereo phone plug for 850, 550, and ScienceWorkshop interfaces.

Order Information

Motion Sensor II.....	CI-6742A
Recommended:	
Motion Sensor Guard	SE-7256
Motion Sensor Bracket.....	PS-2546
Cart Adapter Accessory	ME-6743

Motion Sensor Guard

SE-7256

Use this wire guard to protect the Motion Sensor when dropping objects from above.



Order Information

Motion Sensor Guard	SE-7256
---------------------------	---------

Motion Sensor Bracket

PS-2546

This magnetic bracket allows a Motion Sensor to be easily hung from a drop ceiling. Simply screw the bracket into the 1/4"-20 threads on the sensor and use the included adjustment nut to hold the sensor in the desired orientation.



The bracket can also be used to hold the Motion Sensor on vertical surfaces such as filing cabinets and magnetic whiteboards.

Order Information

Motion Sensor Bracket.....	PS-2546
----------------------------	---------

Cart Adapter Accessory

ME-6743

The Cart Adapter Accessory allows the Motion Sensor and many other sensors to be mounted to a Dynamics Cart or a PAScar.

Mounting a Motion Sensor on a cart is ideal for the study of relative motion. The adjustment knob on the bracket allows the Motion Sensor to face any direction.

Includes:

- Two M5 thumb screws to attach to cart
- 1/4"-20 screw at center



The adjustment knob on the bracket allows the Motion Sensor to face any direction.

Order Information

Cart Adapter Accessory.....	ME-6743
-----------------------------	---------

Rotary Motion Sensor

CI-6538

Measure angle and angular velocity or measure distance and linear velocity using the rack or the pulley. This sensor is also bi-directional, indicating the direction of motion.



Specifications:

Resolution: 1°/0.087 mm and 0.25°/0.022 mm (software selectable)

Maximum Speeds: 13 rev/sec at 1° resolution (360 data points/revolution); 3.25 rev/sec at 0.25° resolution (1440 data points/revolution)

Optical Encoder: Bidirectional, indicates direction of motion

Connector: Dual stereo phone plug for 850, 550, and ScienceWorkshop interfaces

Order Information

Rotary Motion Sensor	CI-6538
Recommended:	
Linear Motion Accessory	CI-6688A p.35
3-Step Pulley	CI-6693

Force Sensor

CI-6537

PASCO's durable, reliable Force Sensor has been designed specifically for the student physics lab. Its wide-range, high-frequency response and low noise transducer help generate excellent impulse graphs, smooth harmonic motion data, and more. The sensor's special strain gauge consistently generates the same output for the same force and is designed to minimize side loads. Damping materials reduce vibrations caused by collisions without affecting results. Any dynamics cart accessory can be mounted on top of the Force Sensor.



Specifications:

Force Range: ±50 N

Resolution: 0.03 N or 3.1 grams

Zero (Tare) Function: Push-button

Force-overload Protection: Mechanical stop prevents forces of more than 50 N from damaging the sensor

Pin Configuration: 8-pin DIN plug mounts on standard 12.7 mm support rods

Maximum Sample Rate: up to 10 MHz (depending on interface)

Order Information

Force Sensor	CI-6537
--------------------	---------

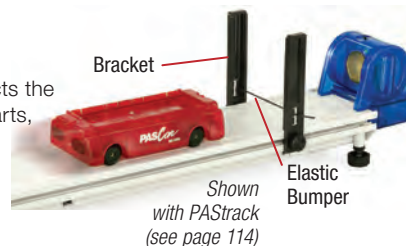
Elastic Bumper

ME-8998

The Elastic Bumper protects the Motion Sensor from the carts, but doesn't interfere with the ultrasonic pulse.

Includes:

- Two pairs of brackets
- 10 meters of elastic material



Order Information

Elastic Bumper	ME-8998
----------------------	---------

Photogate Head

ME-9498A

The Photogate Head monitors the motion of objects passing through its gate, counting events as the object breaks the infrared beam.

Specifications:

Photogate Width: 7.5 cm

Fall Time: < 50 ns

Spatial Resolution: < 1 mm

Timing Resolution: 0.1 millisecond

Connector: Stereo phone plug



Order Information

Photogate Head	ME-9498A
Recommended:	
Photogate Stand	ME-9805

Accessory Photogate

ME-9204B

Applications:

- ▶ Conduct basic position, velocity and acceleration experiments
- ▶ Measure acceleration due to gravity (free fall)
- ▶ Measure pendulum periods

Includes both a Photogate Head and a Photogate Stand for flexible experiment design. The Photogate Stand is also sold separately.

Includes:

- Photogate Head (ME-9498A)
- Photogate Stand (ME-9805)



Order Information

Accessory Photogate	ME-9204B
Photogate Stand	ME-9805

Photogate & Pulley System

ME-6838A

Specifications:

Pulley Diameter: 5.1 cm (2")

Pulley Mass (approx.): 5 g

Pulley Outside Circumference: 16 cm (6.3")

Pulley Groove Circumference: 15 cm (5.9")

Pulley Coefficient of Friction: $< 7 \times 10^{-3}$

Pulley Moment of Inertia (approx.): $1.8 \times 10^{-6} \text{ kg} \cdot \text{m}^2$

Photogate Width: 7.5 cm

Photogate Signal Fall Time: < 50 ns

Photogate Spatial Resolution: < 1 mm

Timing Resolution: 0.1 millisecond

Connector: Stereo phone plug

Includes:

- Photogate Head
- Super Pulley with Rod



Order Information

Photogate & Pulley System	ME-6838A
---------------------------------	----------

Time-of-Flight Accessory

ME-6810A

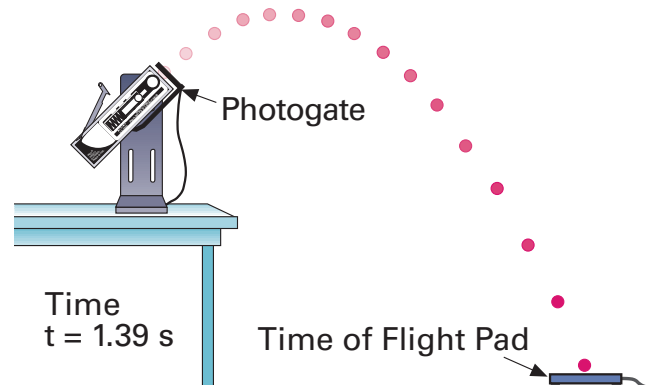


Applications:

- ▶ Conduct freefall experiments
- ▶ Use with all PASCO launchers
- ▶ Horizontal Velocity is Constant
- ▶ Horizontal Distance (two Photogate Heads needed)
- ▶ Time-of-Flight Versus Initial Velocity

The Time-of-Flight Accessory is designed primarily for freefall or projectile experiments. When an object hits the plate, a signal is sent to the interface.

Note: When used with the Projectile Launcher, a photogate is used to start the timer and the 20' extension cable is recommended.



Order Information

Time-of-Flight Accessory	ME-6810A
--------------------------------	----------

Phone Jack Extender Cable

PI-8117



This 7.6 meter (25 feet) phone jack-to-phone jack extension cord can be used with any Photogate/Timing accessory.

Order Information

Phone Jack Extender Cable (20' cable)	PI-8117
---	---------

Sound and Electrometer

Sound Sensor with Microphone

UI-5101

The Sound Sensor houses a sensitive microphone designed to measure the relative intensity of sound and display the audio waveforms of sound levels between 45 and 100 dB, when used in conjunction with the 550 or 850 Universal Interface and PASCO software.

Also see the
Wireless Sound
Sensor
on page 62.



Applications:

- Measure basic sound intensity
- Measure speed of sound measurement
- Measure beats
- Study the doppler effect
- Conduct voice studies
- Learn musical instrument overtones

Specifications:

Frequency Response: 20 to 9,000 Hz

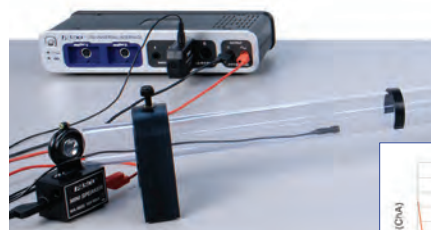
Decibel Range: 45 to >100 dB

Signal-to-Noise Ratio: < 60 dB

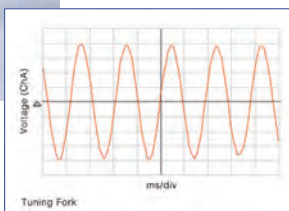
Amplification: Two stages condition low-level signals

Pin Configuration: 8-pin DIN plug on case

Sensor ID: Auto-identification on 550/850 Interfaces



The included auxiliary microphone can be used to probe a resonance tube.



Includes:

- Auxiliary Microphone (UI-5102)
- 8-Pin DIN Extension Cable
- Sensor Mounting Rod

Order Information

Sound Sensor with Microphone.....UI-5101

Replacement:

Auxiliary MicrophoneUI-5102

Temperature Sensor

CI-6605A

- Rugged sensor

PASCO's Stainless Steel Temperature Sensor offers a superior range, resolution and accuracy.

Specifications:

Temperature Range: -35°C to +135°C

Accuracy: $\pm 0.5^\circ\text{C}$

Resolution: 0.05°C

Pin Configuration: 8-pin DIN plug



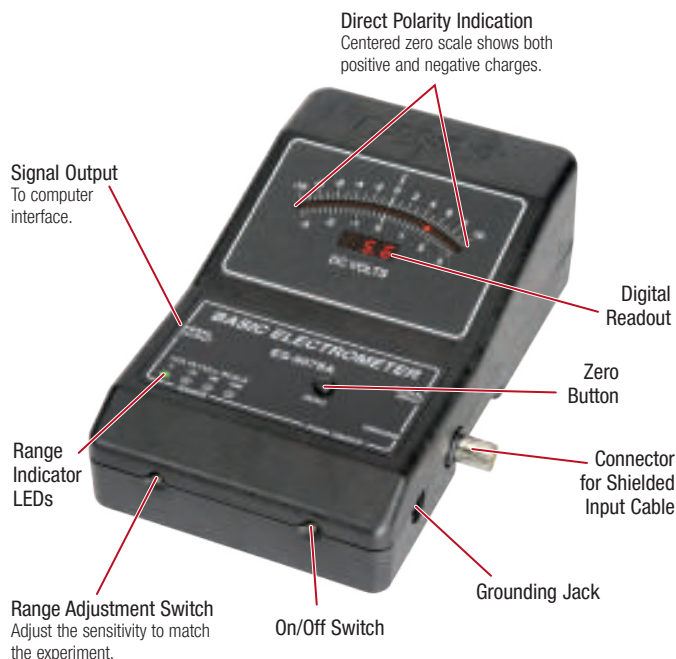
Order Information

Temperature SensorCI-6605A

Basic Electrometer

ES-9078A

- For 550/850 and ScienceWorkshop Interfaces



The PASCO Basic Electrometer is a quantitative electroscopes, measuring the polarity and magnitude of charged objects. With almost infinite input resistance (10^{14} ohm), the Electrometer is a high-impedance voltmeter, draining almost no charge from the object it is measuring.

Features:

- **Center-Zero Meter:** Polarity is indicated directly.
- **Switch-Selectable Ranges:** 3, 10, 30 and 100 VDC. LED lights indicate the range in use.
- **Zeroing Switch:** Removes all charge from the input and brings the meter to zero.
- **Automatic Shutoff:** Turns off about 3 hours after turned on (or used in any way).
- **Output Compatible with PASCO Interfaces:** The interface cable included with the electrometer connects directly to an analog channel on a ScienceWorkshop interface, and connects to a PASPORT interface through an Analog Adapter. This enables the output signal from the electrometer to be recorded, displayed, and analyzed by the data acquisition software.
- **Battery Operation:** 4 "AA" cells included. Range indicator lights flash when batteries need to be replaced.

Includes:

- Shielded input cable to connect the Electrometer to the Faraday Ice Pail or other source of charge
- Grounding cable with clip
- Interface cable
- Instruction and experiment manual

Order Information

Basic Electrometer.....ES-9078A

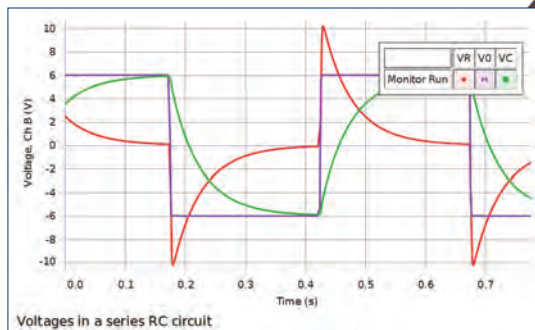
For 550/850 Interfaces and High Speed Sampling:

Voltage Sensor UI-5100/UI-5110 Current Probe PS-2184

When you're measuring voltage and current in AC circuits and need to sample fast, these sensors can sample as fast as 10 MHz on an 850 Universal Interface and up to 2 MHz on a 550 Universal Interface. The Voltage Sensors plug into the analog ports of these interfaces. The Current Probe is attached to the Voltage Sensor to measure the voltage drop across a precision $0.10\ \Omega$ resistor and outputs the resultant current calculation.

Since the 850 Interface analog gain can be set to $\times 1000$, very small currents ($0.024\ \text{mA}$ resolution) can be read with the Current Probe.

The 850 Universal Interface can measure at a rate of 10 MHz on two channels simultaneously; 1 MHz on three or four channels simultaneously. The 550 Universal Interface has a maximum sample rate of 2 MHz on one channel; 1 MHz on two channels simultaneously.



The high speed of the 850 Universal Interface, in Scope Mode, allows the examination of time varying voltages in an RC circuit to verify that Kirchhoff's loop theorem holds even when voltage is not constant.

Voltage Sensor

UI-5100 (unshrouded)

UI-5110 (shrouded)



This voltage sensor plugs into any analog channel on a ScienceWorkshop Interface, the 850 Universal Interface, and the 550 Universal Interface. The voltage range and frequency response depend on the interface. When the Voltage Sensor is plugged into either the 550 or 850 Universal Interface, the sensor is automatically recognized.

Specifications:

Voltage Range with 850 Interface:
 $\pm 20\ \text{V AC/DC}$ (850 Interface)

Voltage Range with Other Interface:
 $\pm 10\ \text{V AC/DC}$ (other than 850)

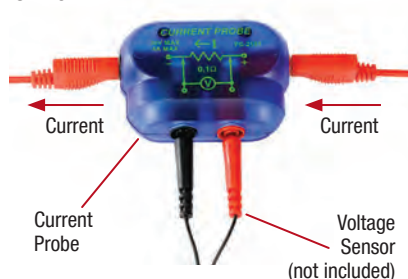
Product Pin Configuration: 8-pin DIN plug. Probe ends are standard banana plugs. Two alligator clip adapters included.

Order Information

Voltage Sensor
(unshrouded) UI-5100
Voltage Sensor
(shrouded) UI-5110

Current Probe

PS-2184



The PS-2184 attaches to any PASCO voltage sensor to allow the measurement of current between $-4\ \text{A}$ and $+4\ \text{A}$. The probe contains a precision $0.10\ \text{ohm}$ resistor and allows the precise measurement of the voltage drop across the resistor.

Specifications:

Resistor: $0.10\ \text{Ohm}$, $3.0\ \text{W}$, 1.0%

Maximum Current: $4\ \text{A}$

Maximum Voltage without Damage: $30\ \text{V}$

Terminals: $4\ \text{mm}$ Banana Jacks

Maximum Sample Rate: Depends on interface

Order Information

Current Probe PS-2184

Current Sensor

CI-6556



The Current Sensor determines the current through it by measuring the voltage across the internal $1.00\ \Omega$ resistor. Up to $1.5\ \text{A}$ can be measured.

Specifications:

Maximum Current Input: $1.5\ \text{A}^*$

Maximum Differential Voltage: $1.5\ \text{V}^*$

Maximum Common Mode Voltage: $10\ \text{V}$

Resolution: $5\ \text{mA}$ ($1\times$ gain), $0.5\ \text{mA}$

Pin Configuration: 5-pin DIN on box
 $^*\text{DC or AC RMS (root mean square)}$

Order Information

Current Sensor CI-6556

Light/Magnetic Field

Light Sensor

CI-6504A



Applications:

- ▶ Measure relative light intensities in daylight (even monitor a solar eclipse)
- ▶ Compare light intensity vs. distance
- ▶ Study interference/diffraction/polarization

PASCO's Light Sensor is ideal for indoor and outdoor relative light intensity experiments. It can be used in a lighted room for most experiments.

Specifications:

Sensing Element: Si PIN photodiode

Spectral Response: 320 nm to 1100 nm

Gain Levels: 100x, 10x, 1x, (switch-selectable)

Output Voltage: 0 V to 5 V

Pin Configuration: 5-pin DIN plug on case

Maximum Light Intensity Levels (lux):

Approximate Lux 5, 50, 500

Resolution: 0.0001 lux maximum

Order Information

Light Sensor CI-6504A

High-Sensitivity Light Sensor

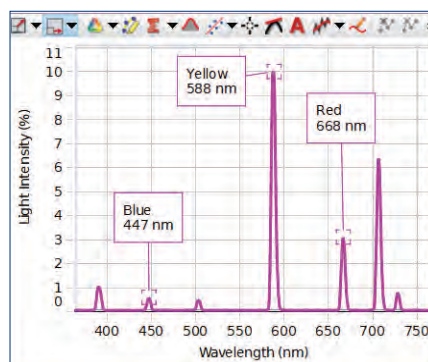
CI-6604



Applications:

- ▶ Spectrophotometry
- ▶ Interference and diffraction patterns
- ▶ Measure light intensity vs. distance

The High-Sensitivity Light Sensor is designed for experiments involving low light level conditions.



Helium spectrum recorded using the High Sensitivity Light Sensor and the OS-8539 Educational Spectrophotometer System.

Specifications:

Sensing Element: Si PIN photodiode

Spectral Response: 320 nm – 1100 nm

Gain Levels: 100X, 10X, 1X (switch-selectable)

Resolution: 10 μ lux at the highest gain level.

Range: 0 to 5 lux

Range: 0 to 0.5 lux

Range: 0 to 0.05 lux

Maximum Sample Rate: Interface dependent

Output Voltage: 0V – 5V

Order Information

High-Sensitivity
Light Sensor CI-6604

Magnetic Field Sensor

CI-6520A

- ▶ Measures radial or axial fields
- ▶ High sample rate



Also see the
Wireless 3-Axis
Magnetic Field
Sensor on
page 64.

PASCO's Magnetic Field Sensor is sensitive enough to detect Earth's magnetic field. Its application in the physics lab includes measuring and plotting fields in single or Helmholtz coils, solenoids, electromagnets and magnets.

Features

- ▶ **Measures Radial or Axial Fields:** Two switch-selectable Hall Effect sensors measure either radial or axial fields.
- ▶ **Tare Button:** Zeroing or nulling out existing fields is accomplished by just pushing the Tare button.
- ▶ **Three Switchable Ranges of Sensitivity:** Full scale ranges of 10, 100 and 1,000 gauss.
- ▶ **7.5 cm Probe:** Sensors are mounted at the end of a fully encapsulated 7.5 cm long probe.

Specifications:

Sensitivity:

± 10 gauss (100X Gain),

50 mG resolution, 1 G Accuracy

± 100 gauss (10X Gain),

50 mG resolution, 10 G Accuracy

± 1000 gauss (1X Gain),

500 mG resolution, 100 G Accuracy

Measurement Modes: Axial and Radial

Probe Length: 7.5 cm

Pin Configuration: 8-Pin DIN plug on case

Order Information

Magnetic Field Sensor CI-6520A

Replacement:

Zero Gauss Chamber EM-8652

Zero Gauss Chamber

EM-8652

This double-walled, high permeability metal chamber produces a zero gauss field within the chamber. By placing the Magnetic Field Sensor probe into the chamber and pushing the "Tare" button, the sensor may be zeroed. Highly recommended for measurement of Earth's magnetic field.



Order Information

Zero Gauss Chamber EM-8652

Digital PASPORT Sensor Index

PASPORT Sensors:

- Have digital outputs that allow multiple measurements per channel with reduced noise
- Compatible with all current PASCO interfaces, as well as discontinued PASPORT interfaces

Sensor Description	Product #	Page #
Current, High	PS-2193	43
Current Probe	PS-2184	43
Digital Adapter	PS-2159	31
Displacement Sensor	PS-2204	38
Flow, General	PS-2222	45
Flow, General w/Venturi Tube	PS-2225	45
Flow, General w/Pitot Tube	PS-2226	45
Force	PS-2104	36
Force, High Resolution	PS-2189	36
Force Platform	PS-2141	37
Force Platform (2-Axis)	PS-2142	37
Galvanometer	PS-2160	44
Human Arm Model	PS-2611	46-47
Light, Broad Spectrum	PS-2150	42
Light, High Sensitivity	PS-2176	42
Load Cell & Amplifier Sets	PS-2199	38
Load Cell Amplifiers	PS-2198	38
Load Cell, 5N	PS-2201	38
Load Cell, 100N	PS-2200	38

Sensor Description	Product #	Page #
Magnetic Field (2-Axis)	PS-2162	44
Motion	PS-2103A	34
Photogate Head	ME-9498A	33
Pressure, Absolute	PS-2107	39
Pressure, Dual	PS-2181	39
Pressure/Temperature	PS-2146	39
Rotary Motion PASPORT	PS-2120A	35
Smart Gate	PS-2180	32
Temperature	PS-2125	40
Temperature, Fast Response	PS-2135	40
Temperature, Skin/Surface	PS-2131	40
Temperature, Stainless Steel	PS-2153	40
Temperature, Quad	PS-2143	40
Temperature, Non-Contact	PS-2197	41
Temperature, Type K	PS-2134	41
Time-of-Flight Accessory	ME-6810A	33
Voltage/Current	PS-2115	43

PASPORT Sensor Extension Cable

PS-2500



The PASPORT Sensor Extension Cable extends the distance a PASPORT sensor can reach by 2 m. Two cables CANNOT be connected together or used on a sensor that already has a cable.

Order Information

PASPORT Sensor Extension CablePS-2500

8-Pin DIN Extension Cable

UI-5218



The 1.8 m long Extension Cable allows ScienceWorkshop Sensors to be used further away from the interface. Multiple cables can be used in series. It is compatible with the 500, 750 (discontinued), and 850 Interfaces.

Order Information

8-Pin DIN Extension CableUI-5218

PASPORT Digital Adapter

PS-2159



The Digital Adapter is required when photogates, timing and counting sensors are used with any PASPORT interface. Each Digital Adapter accommodates two sensors at once. Each port on the Digital Adapter automatically detects a connection and initiates a selection of pre-configured or user-defined options. Several Digital Adapters can be used simultaneously when required.

Order Information

PASPORT Digital Adapter.....PS-2159

Smart Gate

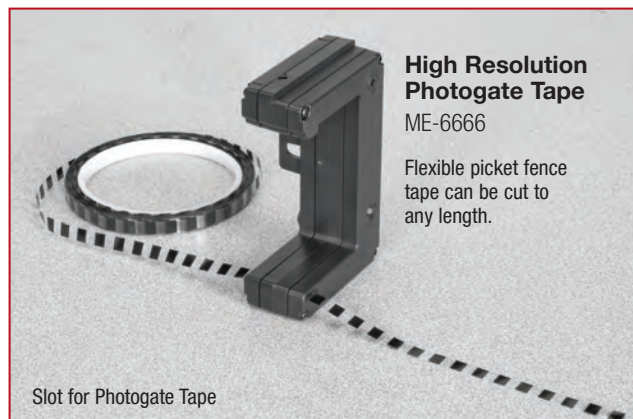
Smart Gate *It's four photogates in one!*

PS-2180

- ▶ Dual Photogate beams
- ▶ Photogate Tape Slot
- ▶ Daisy-chain auxiliary Photogate or Time-of-Flight

Also see the
Wireless
Smart Gate
on page 54.

The Smart Gate connects directly to any PASPORT interface, and has an auxiliary port to daisy-chain to an additional Photogate. Can be used with a Cart Picket Fence, Clamp-On Super Pulley, and flexible Photogate Tape.



Connects directly to a PASPORT interface.



Laser Switch

Shine any laser onto the built-in receiver to time large objects.

**Includes:**

- Smart Gate
- PASPORT Cable
- Interface Cord

Dual photogate beams.

Directly measure speed with a single Smart Gate.

Order Information

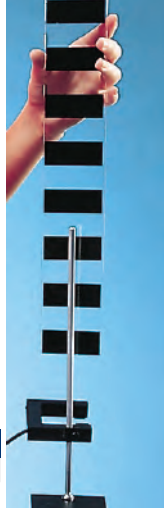
Smart Gate	PS-2180
Recommended:	
Time-of-Flight Accessory	ME-6810A
Photogate Tape, High Resolution (30 m)	ME-6666
Required:	
PASPORT Interface	

Picket Fence

ME-9377A

Conduct freefall experiments by dropping this Picket Fence through the PASCO Photogate.

The distance from the leading edge of each black bar to the leading edge of the next black bar is 5.0 cm. The Picket Fence has eight black bars and is 40 cm long.



Order Information

Picket Fence ME-9377A

Cart Picket Fences (2 pack)

ME-9804



Order Information

Cart Picket Fences (2 pack) ME-9804

Picket Fences (Smart Timer) (set of 2)

ME-8933

See Smart Timer on pages 124-125.



Order Information

Picket Fences (Smart Timer) ME-8933

Photogate Tape, High Resolution (30 m)

ME-6666

This flexible Mylar picket fence tape can be cut to any length. Tape slides into a Smart Gate to more accurately measure the motion of a cart.

Slide the photogate tape through the slot to measure position, velocity, and acceleration. The band spacing on the tape is 1 cm from edge to edge.



Order Information

Photogate Tape, High Resolution (30 m) ME-6666
Recommended:
Smart Gate PS-2180

Phone Jack Extender Cable

PI-8117

This 7.6 meter (25 feet) phone jack-to-phone jack extension cord can be used with any Photogate/Timing accessory.



Order Information

Phone Jack Extender Cable PI-8117

Photogate Head

ME-9498A

The Photogate Head monitors the motion of objects passing through its gate, counting events as the object breaks the infrared beam.

Specifications:

Photogate Width: 7.5 cm

Fall Time: < 50 ns

Spatial Resolution: < 1 mm

Timing Resolution: 0.1 millisecond

Connector: Stereo phone plug



Order Information

Photogate Head ME-9498A
Recommended:
Photogate Stand ME-9805

Time-of-Flight Accessory

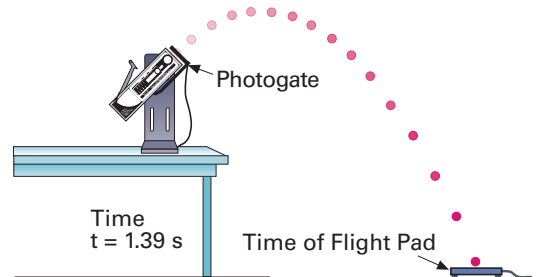
ME-6810A

The Time-of-Flight Accessory is designed primarily for freefall or projectile experiments. When an object hits the plate, a signal is sent to the interface. Note: When used with the Projectile Launcher, a photogate is used to start the timer and the 20' extension cable is recommended.



Applications:

- ▶ Conduct freefall experiments
- ▶ Use with all PASCO launchers
- ▶ Horizontal Velocity is Constant
- ▶ Horizontal Distance (two Photogate Heads needed)
- ▶ Time-of-Flight Versus Initial Velocity



Order Information

Time-of-Flight Accessory ME-6810A

Super Pulley with Mounting Rod

ME-9499

This Super Pulley is mounted on a rigid plastic mounting rod (12.7 mm diameter, 14 cm long) and fits most standard laboratory clamps.



Order Information

Super Pulley with Mounting Rod ME-9499

Motion

PASPORT Motion Sensor

PS-2103A

The PASPORT Motion Sensor is used to measure the position, velocity, and acceleration of a target. The Motion Sensor can be set on a desktop, mounted to a rod stand, or attached to a PASCO Dynamics Track.

**Features:**

- ▶ Measures position, velocity, and acceleration
- ▶ False Target Rejection Technology collects clean data
- ▶ Switch-selectable short range and long range settings
- ▶ Snaps onto PASCO dynamics tracks
- ▶ Mounts to rods for easy positioning
- ▶ 360° pivoting head

Specifications:**Minimum Range:** 0.15 meters**Maximum Range:** 8 meters**Resolution:** 1 mm**Maximum Sample Rate:** 250 Hz**Transducer Rotation:** 360°

Narrow Near/Far Switch Settings: For distances up to 2 meters to reject false target signals or ignore air track noise.

Standard Near/Far Switch Settings: For longer distances up to 8 meters.

Cable Length: 1.8 meter**Mounting Options:** Non-skid rubber feet for table mount

Maximum Ranges at Higher Sample Rates: 1.72 m (at 100 Hz); 0.86 m (at 200 Hz); 0.69 m (at 250 Hz)

Order Information

PASPORT Motion Sensor	PS-2103A
Recommended:	
Motion Sensor Guard	SE-7256
Motion Sensor Bracket.....	PS-2546
Cart Adapter Accessory.....	ME-6743

PASCO MatchGraph!

- ▶ Students feel the motion firsthand and learn how to interpret motion graphs! Watch your students compete to get the best match score.
- ▶ The sample graphs to match include both Position vs. Time and Velocity vs. Time.
- ▶ The student moves back and forth in front of a motion sensor in an attempt to match the motion represented on the graph.

FREE MatchGraph!™ Software

Go to **pasco.com/downloads** and click on MatchGraph.

**Now works
with all
Motion
Sensors and
Smart Carts!**

**See page 14
for more info.**

Motion Sensor Guard

SE-7256

Use this wire guard to protect the Motion Sensor when dropping objects from above.

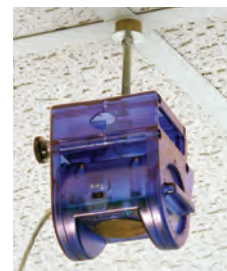
**Order Information**

Motion Sensor Guard	SE-7256
---------------------------	---------

Motion Sensor Bracket

PS-2546

This magnetic bracket allows a Motion Sensor to be easily hung from a drop ceiling. Simply screw the bracket into the 1/4"-20 threads on the sensor and use the included adjustment nut to hold the sensor in the desired orientation.

**Order Information**

Motion Sensor Bracket.....	PS-2546
----------------------------	---------

Cart Adapter Accessory

ME-6743

The Cart Adapter Accessory allows the Motion Sensor and many other sensors to be mounted to a Dynamics Cart or a PAScar.

**Order Information**

Cart Adapter Accessory	ME-6743
------------------------------	---------



Download FREE *MatchGraph!* software for Mac® and Windows® computers at **pasco.com**. Download the free iPad® or Android™ app on the App Store or Google Play.

**Order Information**

Required:		
Wireless Motion Sensor	PS-3219	p. 53
OR		
PASPORT Motion Sensor	PS-2103A	
OR		
Motion Sensor II.....	CI-6742A	p. 26
*Requires a USB or Bluetooth interface.		
OR		
Smart Cart (Red)	ME-1240	p. 52

PASPORT Rotary Motion Sensor

PS-2120A



The PASPORT Rotary Motion Sensor is used to measure position, velocity, and acceleration, both angular and linear, with high resolution (4000 divisions/rev). The maximum spin rate is 30 rev/sec.

How it Works: The Rotary Motion Sensor detects the angle with an optical encoder which interrupts the light beam 4000 times per revolution of the Rotary Motion Sensor shaft. The 6.35 mm diameter, dual ball-bearing shaft extends from both sides of the unit so objects can be attached to either side. The rod clamp, which can be attached to three sides of the sensor, allows the unit to be mounted in almost any orientation. It has a three-step pulley to vary the applied torque. The PASCO Super Pulley with Clamp can be clamped to the platform on the Rotary Motion Sensor to apply a torque with a hanging mass.

Specifications:

Three-step Pulley: 10 mm, 29 mm, and 48 mm diameters

Sensor Dimensions: 10 cm x 5 cm x 3.75 cm,
6.35 mm diameter shaft

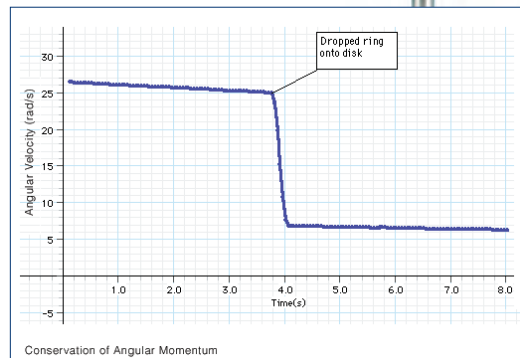
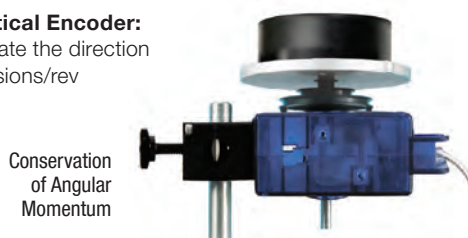
Rotary Motion Resolution: 0.09° (0.00157 rad)

Linear Motion Resolution: 0.0078 mm

Maximum Rotation Rate: 30 revs/sec

Rotary Motion Optical Encoder:

Bidirectional to indicate the direction of motion; 4000 divisions/rev



The angular speed of the disk decreases when the ring is dropped onto the disk.

Rotational Inertia Accessory

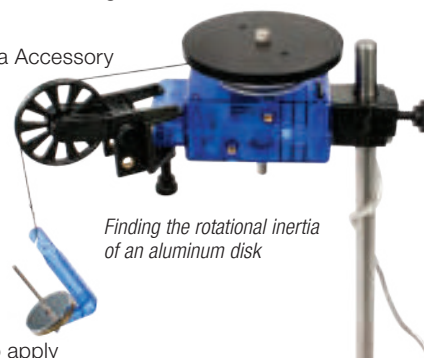
ME-3420

- ▶ Ring and Disk have same mass and outer diameter.
- ▶ Alignment Guide centers the ring on the disk.

Add the Rotational Inertia Accessory

to any PASCO Rotary Motion Sensor to study the oscillations of a pendulum, the rotational inertia of a disk, a steel ring and a metal rod, as well as the conservation of momentum during a rotational collision.

The clamp-on Super Pulley allows students to apply a torque by hanging a mass over the pulley.



Specifications:

Disk Mass: 100 g

Ring Mass: 100 g

Disk Diameter: 8.9 cm

Ring Diameter: 8.9 cm O.D., 8.4 cm I.D.

Rod Mass: 28 g

Rod Dimensions: 0.8 cm diameter, 38 cm long

Brass Masses: 75 g

Alignment Guide Mass: 2 g

Includes:

- Ring And Disk Set (ME-3419)
- Pendulum Accessory (ME-8969)
- Super Pulley with Clamp (ME-9448B)



Order Information

Rotational Inertia Accessory ME-3420

Also available:

Ring And Disk Set ME-3419
(Includes ring, 2 disks, and 3 alignment guides)

Linear Motion Accessory

CI-6688A



Includes:

- Rod Clamp
- Solid aluminum rack

Order Information

Linear Motion Accessory CI-6688A

Order Information

PASPORT Rotary Motion Sensor PS-2120A

Recommended:

Linear Motion Accessory CI-6688A

3-Step Pulley for Rotary Motion Sensor CI-6693

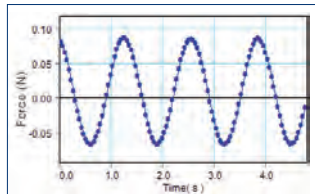
Force

PASPORT High Resolution Force Sensor

PS-2189

- 0.002 N resolution
- Dynamic over-sampling

The PASPORT High Resolution Force Sensor offers a higher resolution than the PS-2104. It features a variable over-sampling rate that reduces measurement noise at lower sampling rates. The digital design minimizes drift, ensuring that the tare holds for hours. You can use this force sensor as a pan balance for long-term experiments, such as investigating the evaporation of liquids, like alcohol or liquid nitrogen, and the sublimation of dry ice.

Specifications:**Range:** ± 50 N**Resolution:** 0.002 N**Zero (Tare) Function:** Push-button**Maximum Sample Rate:** 1 kHz; 2 kHz with the 550 and 850 interfaces**Force Overload Protection:** Up to 75 N

Graph shows force data for the oscillation of a mass and spring system.

The High Resolution Force Sensor has 10 times the resolution of the PS-2104, and can measure changes in force of less than 0.01 N.

The digital design of the PS-2189 results in very little drift, ensuring that the tare will hold for hours. You can use this force sensor as a pan balance for long-term experiments, like investigating the evaporation of liquids such as alcohol or liquid nitrogen, and the sublimation of dry ice!

Order Information

PASPORT High Resolution Force Sensor PS-2189

Shown in use with:

Mass and Hanger Set..... ME-8979 p. 215

IDS Spring Kit ME-8999 p. 182

Force Sensor Balance Stand

CI-6460

Includes:

- Metal Force Sensor Stand
- Pan Balance

Order Information

Force Sensor Balance Stand CI-6460

PASPORT Force Sensor

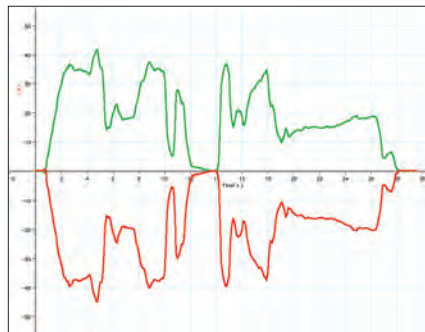
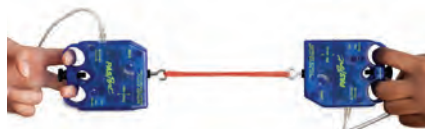
PS-2104

- Binocular force beam minimizes side force measurements

The sensor includes an overload stop in the force beam and a polycarbonate, plastic case to protect it from damage. Finger holes are provided for handheld use, but the sensor can also be mounted directly to a PASCO Dynamics Cart or a 0.5" rod stand.

Applications:

- Measure force exerted by an oscillating mass
- Measure force during elastic and inelastic collisions
- Measure force of a swinging pendulum

Specifications:**Range:** ± 50 N**Resolution:** 0.03 N**Zero (Tare) Function:** Push-button**Maximum Sample Rate:** 1 kHz; 5 kHz with the 550 and 850 interfaces**Force Overload Protection:** Up to 75 N without damage

This graph displays Newton's Third Law during a "Tug of War" experiment.

Includes:

- Bumper Attachment
- Hook Attachment
- Cart/Bracket Thumbscrew
- Rod Clamp Thumbscrew

Order Information

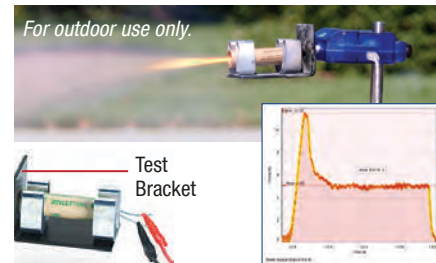
PASPORT Force Sensor PS-2104

Rocket Engine Test Bracket

ME-6617

- A perfect supplement for rocketry studies

With the Rocket Engine Test Bracket attached to a Force Sensor (ScienceWorkshop or PASPORT), students can measure and graphically display the impulse of Estes™ and other model rocket engines. A perfect supplement for rocketry studies. Accommodates rocket engine sizes A, B, C and D.

**Order Information**

Rocket Engine Test Bracket.....ME-6617

Bumper Accessory Set

ME-9884

Includes:

- Stiff Spring
- Light Spring
- Empty Cup (2)
- Modeling Clay

**Order Information**

Bumper Accessory Set..... ME-9884

Magnetic Bumper Set

ME-9885A

Includes:

- Magnetic Bumper (2)

**Order Information**

Magnetic Bumper Set ME-9885A

Force Sensor Track Bracket

ME-6622

Includes:

- Spring Bumpers (2) (different spring constants)
- Magnetic Bumper
- Rubber Bumper
- Clay Cup for Inelastic Collisions (clay included)
- #0 Phillips Head Screwdriver (to attach to Force Sensor)

**Order Information**

Force Sensor Track Bracket ME-6622

PASPORT Force Platform

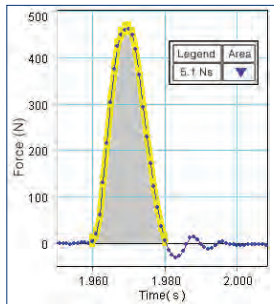
PS-2141

- Rugged design
- Force overload protection
- Large jumping and landing surface



Also see the
Wireless Force
Platforms
on page 56.

The sturdy, glass-filled nylon platform is supported by four force beams that measure the total force acting on the platform. You can use the Force Platform to measure the static weight of a structure or person, as well as the dynamic, vertical force created when moving or jumping. The platform can be placed on a floor or tabletop to measure vertical force, and mounted to a wall to measure horizontal force.



Impulse data
for a bouncing
playground ball.



Applications:

- Determine hang time by jumping from and landing on the platform.
- Measure impulse and maximum force.
- Measure the normal force acting on a person riding an elevator.
- Use two Force Platforms to investigate Newton's Third Law.
- Use a Motion Sensor and a ball to compare the impulse and change in momentum as the ball collides with the platform.

Specifications:

Range: -1100 N to +4400 N

Force Overload Protection: up to 6600 N (1500 lb, 1700 N or 375 lb per beam)

Platform Size: 35 cm x 35 cm

Zero (tare) Function: Push-button

Max Sample Rate: 1000 Hz (2000 Hz with the 850 Interface)

Resolution: 0.1 N

Mass: 4 kg (without handles)

Order Information

PASPORT Force Platform..... PS-2141
Recommended:
Handle Set, Force Platform..... PS-2548

PASPORT 2-Axis Force Platform

PS-2142

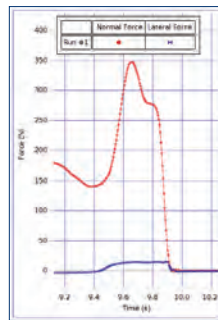
- Large jumping and landing surface



The 2-axis Force Platform has a second plate that rides on rollers along a base to measure the force parallel to the platform. There are a total of five force beams: four corner beams to measure the normal force and a fifth beam to measure the parallel (sideways) force.

Applications:

- Measure the sideways force during a broad jump.
- Measure the normal and parallel forces on a wall as a ladder leans against the wall.
- Measure the normal and parallel forces as a person walks or runs across the platform.
- Pull an object across the platform and measure the normal and frictional forces.



The normal
and parallel
forces are
recorded as
the girl
jumps off the
platform.

Developed in
cooperation with
Nancy Beverly,
Associate
Professor of
Physics at Mercy
College, Dobbs
Ferry, New
York.



Specifications:

Range: -1100 N to +4400 N
(in normal direction)
-1100 N to +1100 N
(in parallel direction)

Platform Size: 35 cm x 35 cm

Platform Mass: 6.4 kg (without handles)

Zero (tare) Function: Push-button Force Overload Protection

Max Sample Rate: 1000 Hz (2000 Hz with the 850 Interface)

Resolution: 0.1 N

Order Information

PASPORT 2-Axis Force Platform..... PS-2142
Recommended:
Handle Set, Force Platform..... PS-2548

Handle Set, Force Platform

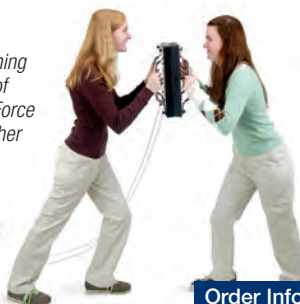
PS-2548

Confirm Newton's Third Law by pushing on a Force Platform using two sets of handles. The handles bolt onto the Force Platform and can be mounted on either side or both sides.



Includes:

- Sturdy metal handles (2)



A real-life
statics
problem can
be analyzed
by standing
on a 2-Axis
Force Platform
while pushing
against the
wall with a
1-Axis Force
Platform.



Order Information

Handle Set, Force Platform..... PS-2548

Force Platform Structure Bracket

ME-6988A

Includes:

- Brackets (2)
- Screws (4)



Order Information

Force Platform Structure
Bracket..... ME-6988A

Load Cells/Displacement

Two ranges of Load Cells

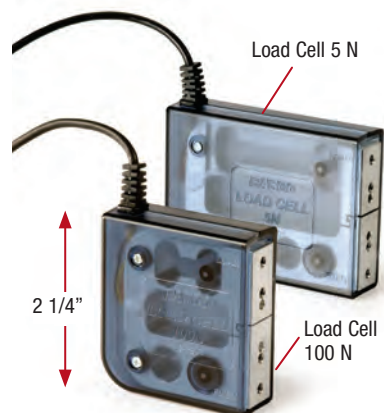
Load Cell 100 N

PS-2200

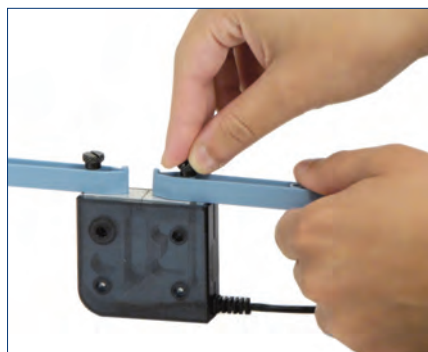
Load Cell 5 N

PS-2201

Also see the
Wireless
Load Cell
on page 55.



Load Cells are available in two different ranges: ± 100 N and ± 5 N. Both types of Load Cells can be used with the same amplifier in any combination. The semi-transparent case lets students see the strain gauge and beam inside.



I-Beams key into the Load Cell and are fastened with thumbscrews.

PS-2200 Specifications:

Range: ± 100 N

Resolution: 0.02 N

Accuracy: $\pm 1\%$ (± 1 N)

Safe Overload: ± 150 N

PS-2201 Specifications:

Range: ± 5 N

Resolution: 0.001 N

Accuracy: $\pm 1\%$ (± 0.05 N)

Safe Overload: ± 7.5 N

Order Information

100 N Load Cell PS-2200
5 N Load Cell PS-2201

PASPORT Load Cell Amplifier

PS-2198



This Load Cell Amplifier can accommodate up to six Load Cells and utilizes a single PASCO interface port to connect to a computer's USB port. Students can insert up to six Load Cells at various points of their structures to extensively analyze their bridges. The Amplifier is compatible with both 5 and 100 N Load Cells, and features a maximum data sampling rate of 500 Hz per port.

Shown in use with
PASCO's Structures
System Truss Set
(ME-6990).
See page 160.



Diagonal Left 6.2 N	Diagonal Right 6.3 N
Lower Left 4.7 N	Lower Right 4.6 N

The top two numbers are the left and right diagonals and the bottom two numbers are the left and right horizontal forces.

Includes:

- PASPORT Load Cell Amplifier (PS-2198)
- Instruction manual

Order Information

PASPORT Load Cell Amplifier PS-2198
Required:
100 N Load Cell PS-2200
5 N Load Cell PS-2201

PS-2199 Includes:

- Load Cell Amplifier
- 100 N Load Cell (4)
- Instruction Manual



Order Information

Load Cell and Amplifier Set PS-2199

PASPORT Dual Load Cell Amplifier

PS-2205



Includes:

- Dual Load Cell Amplifier
- 100 N Load Cell

PS-2206 Includes:

- Load Cell Amplifier (2-port)
- 100 N Load Cell



Order Information

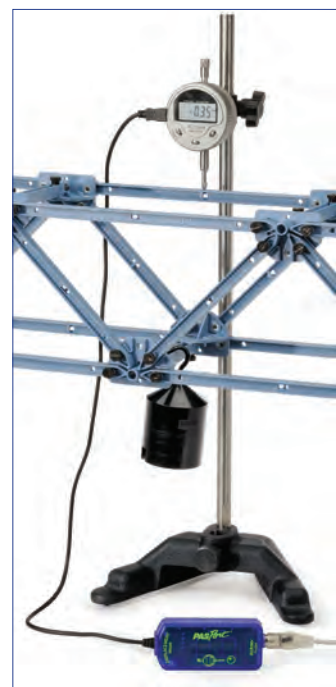
PASPORT Dual Load Cell
Amplifier PS-2205
PASPORT Load Cell and
Dual Amplifier Set PS-2206

Measure bridge deflection with a Displacement Sensor

PASPORT Displacement Sensor

PS-2204

The Displacement Sensor measures the travel of a spring-loaded indicator as a bridge is loaded with weight. The PASPORT Sensor plugs into the included Digital Indicator, which has its own digital LED readout and can be used as a standalone device. To record your data, simply plug the PASPORT sensor into an interface.



Specifications:

Maximum Travel: 10 mm

Maximum Sample Rate: 5 Hz

Resolution: 0.013 mm (0.0005 in)

Includes:

- Sensor
- Bracket
- Dial Gauge



Order Information

PASPORT Displacement
Sensor PS-2204
Shown in use with:
Hooked Mass Set SE-8759 p. 215
Small "A" Base ME-8989 p. 204
Stainless Steel Rod,
60 cm Threaded ME-8977 p. 204

PASPORT Absolute Pressure Sensor

PS-2107

The Absolute Pressure Sensor measures the gas pressure in a container or the surrounding environment. Includes a 20 cc syringe and quick-connect tubing for investigating the Gas Laws. The sensor's wide range makes it an excellent general purpose pressure device.

Applications:

- Measure chemical reaction rates
- Verify Gas Laws (Ideal, Charles', Boyle's)
- Study Vapor Pressure vs. Temperature

Specifications:

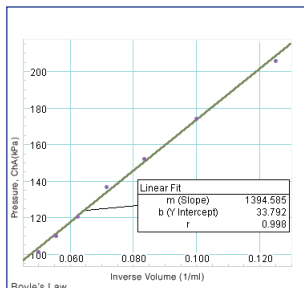
Range: 0 to 700 kPa

Resolution: 0.1 kPa

Accuracy: ± 2 kPa

Maximum Sample Rate: 200 Hz

Repeatability: 1 kPa



The Absolute Pressure Sensor is used in a Boyle's Law experiment in which a syringe is compressed.



Order Information

PASPORT Absolute Pressure SensorPS-2107

PASPORT Dual Pressure Sensor

PS-2181

The Dual Pressure Sensor is capable of reading two absolute pressures, one gauge pressure, or one differential pressure. Dynamic variable oversampling automatically reduces the measurement noise at low sampling rates. Sample rates up to 1000 Hz make studies of both transient and steady-state pressure possible. Includes quick-connect tubing.

Applications:

- Measure pressure in Heat Engine (TD-8572).
- Measure pressure drops in pipes.

Specifications:

Maximum Sample Rate: 1000 Hz

Absolute Pressure: 0 to 200 kPa, 0.01 kPa resolution at 10 Hz and 1 kPa repeatability (displays pressure in kPa, N/m², and psi)

Differential Pressure: ± 100 kPa, 0.01 kPa resolution at 10 Hz and 1 kPa repeatability (displays pressure in kPa, N/m², and psi)



PASPORT Absolute Pressure/Temperature Sensor

PS-2146

This combination sensor is specifically designed for studying the Ideal Gas Law. The included thermistor temperature probe has a fast response time and very low thermal mass.



Applications:

- Extrapolate absolute zero
- Explore Gas Laws (Ideal, Charles', Boyle's)

Specifications:

Maximum Sample Rate: 100 Hz

Pressure Range: 0 to 700 kPa

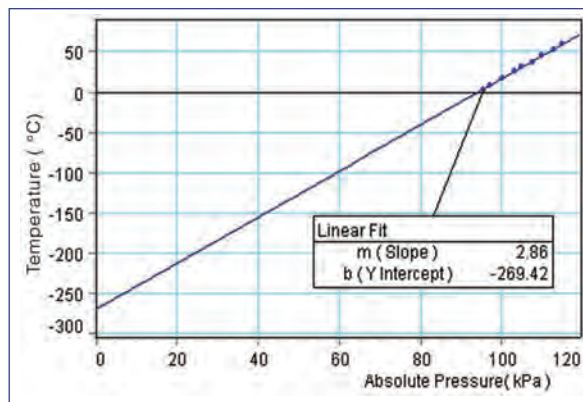
Pressure Resolution: 0.5 kPa

Temperature Range with Included

Fast Response Probe: -10 to 70°C

Temperature Accuracy: $\pm 0.5^\circ\text{C}$

Sensor Extension Cable: Included



Extrapolating Absolute Zero



Measure the pressure and temperature of air in the sphere.

Order Information

PASPORT Absolute Pressure/Temperature SensorPS-2146

Absolute Zero Sphere.....TD-8595 p. 222

Ideal Gas Law ApparatusTD-8596A p. 222

Order Information

PASPORT Dual Pressure SensorPS-2181

Temperature

PASPORT Temperature Sensor

PS-2125

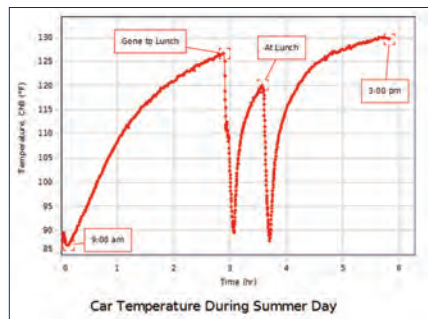
Also see the
Wireless
Temperature
Link on
page 59.



PASCO's Stainless Steel Temperature Sensor offers a superior range, resolution and accuracy. It reports temperature (in °C, °F, or K) whether it is immersed in liquids, held in the air, or touching a solid surface.

Applications:

- ▶ Conduct general temperature experiments
- ▶ Measure rapid temperature changes found in endothermic-exothermic reactions
- ▶ Conduct environmental studies



Capstone graph showing the temperature inside a parked car on a summer day. We turned on the air conditioning when we drove to lunch.

Specifications:

Range: -35°C to +135°C
Resolution: 0.0025°C
Accuracy: ±0.5°C
Maximum Sample Rate: 10 Hz
Displays: °C, K and °F
Repeatability: 0.1°C

Order Information

PASPORT
Temperature Sensor PS-2125

PASPORT Quad Temperature Sensor

PS-2143



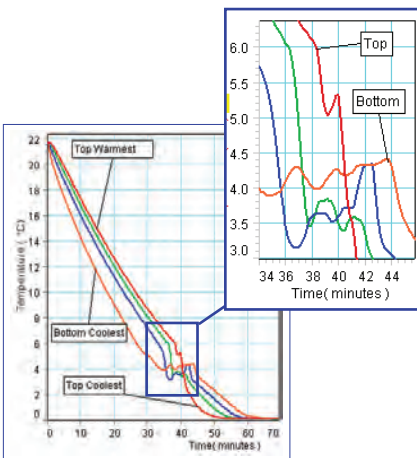
The PASPORT Quad Temperature Sensor can connect up to four Temperature Probes and can be used with our Stainless Steel, Fast Response, and Skin/Surface Temperature probes for a wider variety of temperature measurements in the classroom or field.

Applications:

- ▶ Thermal heat flow (one or two dimension)
- ▶ Compare body temperatures
- ▶ Side-by-side chemical reactions
- ▶ Solar radiation
- ▶ Properties of insulation

Specifications:

Range: -35 to +135°C
Resolution: 0.0025°C
Accuracy: ±0.5°C
Maximum Sample Rate: 100 Hz
Displays: °C, K and °F



Four Fast Response Temperature Probes were used to study the temperature in a glass of water at four different levels as the water was cooled.

Includes:

- Two Stainless Steel Temperature Probes (2)
- Three Fast Response Probes (3)

Order Information

PASPORT Quad
Temperature Sensor PS-2143

Temperature Probes PASPORT Skin/Surface Temperature Probe

PS-2131



- ▶ Flat sensing element ideal for surfaces
- ▶ Quickly reaches equilibrium temperature with surface

Range:

-10 to +70°C

Make a temperature
profile of the
human hand.



Order Information

PASPORT Skin/Surface
Temperature Probe PS-2131

PASPORT Fast Response Temperature Probe (3 pack)

PS-2135



- ▶ Accurately measures temperature changes in real time
- ▶ Ideal for small or hard-to-reach spaces
- ▶ Includes 10 adhesive patches
- ▶ Adhesive patches hold the Temperature Probe in place.

Range: -30 to +105°C

Order Information

PASPORT Fast Response Temperature
Probe (3 pack) PS-2135

PASPORT Stainless Steel Temperature Probe

PS-2153



Range: -35 to +135°C

Order Information

PASPORT Stainless Steel
Temperature Probe PS-2153

Order Information

*All of the probes above require one of the following temperature sensors:

PASPORT Temperature
Sensor PS-2125
 PASPORT Quad Temperature
Sensor PS-2143
 Temperature Sensor CI-6605A p. 28

PASPORT Non-Contact Temperature Sensor

PS-2197

- ▶ Non-contact
- ▶ -70°C to 380°C



The Non-Contact Temperature Sensor measures surface temperature by detecting the emitted infrared light. Record the temperature of objects without touching them!

Applications:

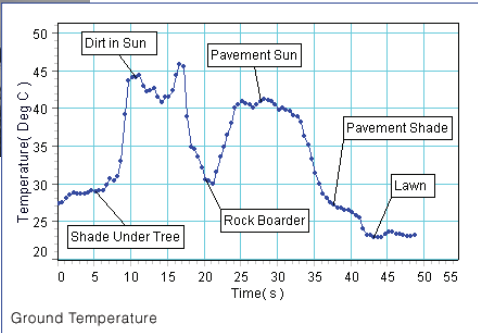
- ▶ Compare temperature of hands, skin, face, and clothes
- ▶ Measure the temperature of different outdoor ground surfaces
- ▶ Map the temperature profile of an exterior wall

Specifications:

Range: -70°C to 380°C
Accuracy: $\pm 0.5^{\circ}\text{C}$
Response Time: Less than 0.1 s
Maximum Sample Rate: 200 Hz
Field of View: $\pm 35^{\circ}$



The student measures the late-morning ground temperature over four distinct surfaces. Starting in the shade under the distant tree, she then crosses bare dirt (in sun), a rock border, pavement, and lawn.



PASPORT Temperature Type K Sensor

PS-2134

- ▶ Extra-long probe



The PS-2134 is a single channel sensor that uses a Type K thermocouple probe to measure temperatures ranging from -200 to +1000°C. Includes one Type K Thermocouple.

Applications:

- ▶ Measure temperatures down to -200°C
- ▶ Measure temperatures in hard-to-reach places
- ▶ Use in high temperature applications where the narrow tip of the probe can be applied without burning the insulation cover (such as a candle flame)

Specifications:

Range: -200°C to +1000°C
Accuracy: $\pm 3^{\circ}\text{C}$ or 3%, whichever is greater
Maximum Sample Rate: 10 Hz



The Type K Temperature Sensor can be used to measure the temperature of a flame. Works with any industry standard Type K thermocouple.

Order Information

PASPORT Temperature Type K Sensor PS-2134
Recommended:
Type K Thermocouple PS-2155

Order Information

PASPORT Non-Contact Temperature Sensor PS-2197
Shown in use with:
PASCO Capstone Software pp. 8-11

Light

PASPORT High Sensitivity Light Sensor

PS-2176

- Ideal for low light experiments



The High Sensitivity Light Sensor supports studies of visible light, ranging from early explorations of sunlight to low intensity spectral studies. Built-in automatic variable oversampling reduces noise.

Applications:

- Spectrophotometry
- Interference and diffraction patterns
- Measure light intensity vs. distance

Specifications:

Sensing Element: Si PIN photodiode

Spectral Response: 320 nm to 1100 nm

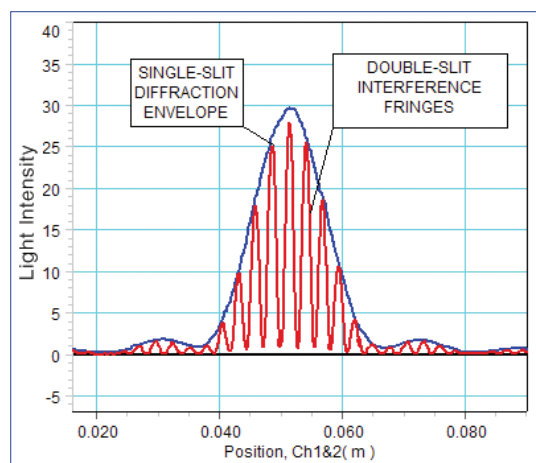
Gain Levels: 10,000x, 100x, 1x, switch selectable

Approximate Lux Ranges: 0 to 1, 0 to 100, 0 to 10,000

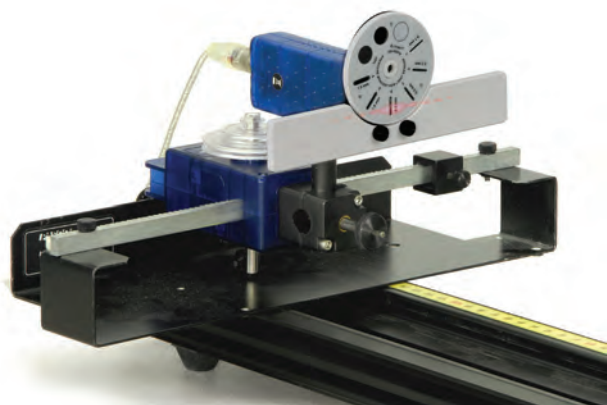
Maximum Sample Rate: 1000 Hz

Resolution: ± 0.01 Lux at 1000 Hz

on 0 to 100 scale; ± 0.0005 Lux at 5 Hz on 0 to 100 scale



Computer scan of a single-slit and double-slit having the same slit width.

**Order Information**

PASPORT High Sensitivity Light Sensor PS-2176

PASPORT Broad Spectrum Light Sensor

PS-2150

- For use with Spectrophotometer
- Ideal for Blackbody Spectrum



The Broad Spectrum Light Sensor is designed specifically for use with our Educational Spectrophotometer System OS-8539 and Prism Spectrophotometer Accessory OS-8543 for Blackbody experiments. The Broad Spectrum Light Sensor uses a thermopile and window combination that respond to both the near infrared and visible light necessary for the Blackbody experiment.

Applications:

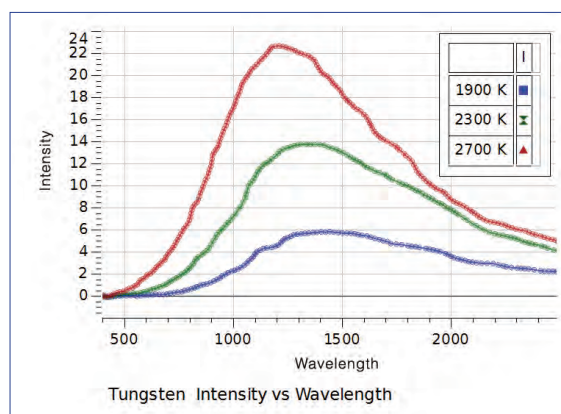
- Blackbody Experiment

Specifications:

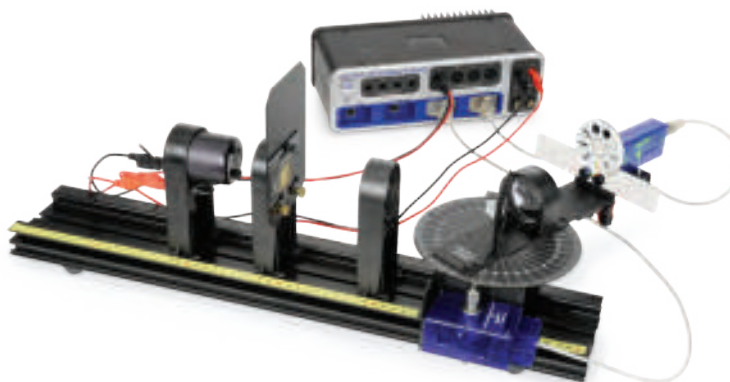
Sensing Element: BaF_2 window, xenon gas-filled thermopile

Spectral Response: 300 to 10,000 nm

Maximum Sample Rate: 100 Hz



The classic textbook diagram of the intensity versus wavelength blackbody curves can be produced with real data. In this graph, the peak wavelength in the blackbody curve shifts as the source temperature is lowered.

**Order Information**

PASPORT Broad Spectrum Light Sensor PS-2150

PASPORT Voltage-Current Sensor

PS-2115

Also see the Wireless Current and Voltage Sensors on page 60.



The PASPORT Voltage-Current Sensor combines voltage and current sensors in one case. It can simultaneously measure voltage, current, and power, then display the collected data in the form of a digital display or graph. An audible beep can be heard when overload protection shuts down the sensor, alerting teachers and keeping students safe. The sensor will automatically reset after the high current is removed.

Applications:

- Study circuit properties for both circuits in series and parallel
- Ohm's Law
- Measure power used by an electrical device
- Indirectly measure the resistance of any circuit element
- Measure the voltage and current associated with RC and LRC circuits

Specifications:

Voltage	Current
Range: ± 10 V	Range: ± 1 A
Resolution: 5 mV	Resolution: 0.5 mA

Current Channel Series Resistance:

0.6 Ω , <0.9 Ω at room temperature

Maximum Common Mode Voltage: 10 V

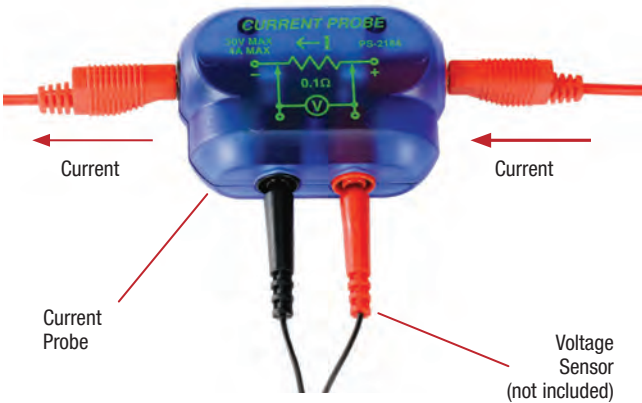
Maximum Sample Rate: 1 kHz

Voltage Input Impedance: 2 M Ω

PASPORT Current Probe

PS-2184

The PS-2184 attaches to any voltage sensor to allow the measurement of current between -4 A and +4 A. The probe contains a precision 0.10 ohm resistor and allows the precise measurement of the voltage drop across the resistor.



Specifications:

- Resistor:** 0.10 Ω , 3.0 W, 1.0%
- Maximum Current:** 4 A
- Maximum Voltage Without Damage:** 30 V
- Terminals:** 4 mm Banana Jacks
- Maximum Sample Rate:** Depends on interface

Order Information	
Current Probe	PS-2184
Required (one of these):	
Wireless Voltage Sensor	PS-3211
Voltage Sensor (shrouded)	UI-5110

Order Information	
PASPORT Voltage-Current Sensor	PS-2115
Recommended:	
Alligator Clip Leads (Set of 10)	EM-8634 p. 247

Galvanometer/Magnetic Field

PASPORT Galvanometer

PS-2160



The Galvanometer Sensor is designed to measure small voltages with high resolution. It includes dynamic variable over-sampling, which greatly reduces the measurement noise at low sampling rates. Shunt resistors are included to allow measurement of current.

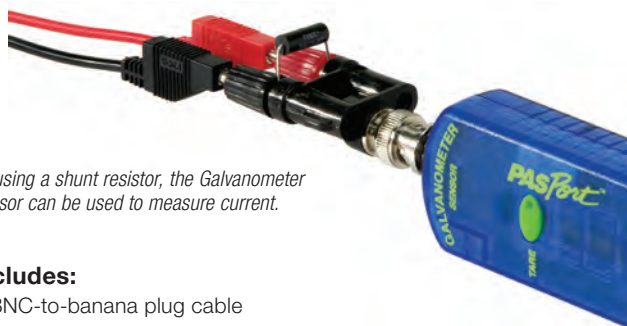
Specifications:

Voltage Range: ± 2000 mV

Resolution: 0.1 mV

Maximum Sample Rate: 1 kHz

Input Impedance: 1 M Ω



By using a shunt resistor, the Galvanometer Sensor can be used to measure current.

Includes:

- BNC-to-banana plug cable
- BNC-to-banana jack adapter
- 0.1 Ω and 10 Ω resistors

Order Information

PASPORT Galvanometer	PS-2160
Recommended:	
Alligator Clip Leads (10 pack)	EM-8634 p. 247

Zero Gauss Chamber

EM-8652

This double-walled, high permeability metal chamber produces a zero gauss field within the chamber. By placing the Magnetic Field Sensor probe into the chamber and pushing the "Tare" button, the sensor may be zeroed. Highly recommended for measurement of Earth's magnetic field.



Order Information

Zero Gauss Chamber	EM-8652
--------------------------	---------

PASPORT 2-Axis Magnetic Field Sensor

PS-2162

- Measures radial and axial fields
- Tare button



Use the PASPORT 2-Axis Magnetic Field Sensor to measure radial and axial fields simultaneously. The built-in dynamic variable over-sampling greatly reduces noise at low sample rates.

Applications:

- Measure Earth's magnetic field.
- Measure magnetic field (magnitude and direction from a coil or a bar magnet).

Specifications:

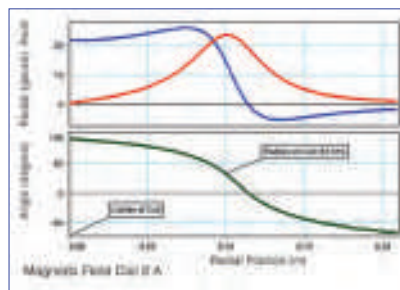
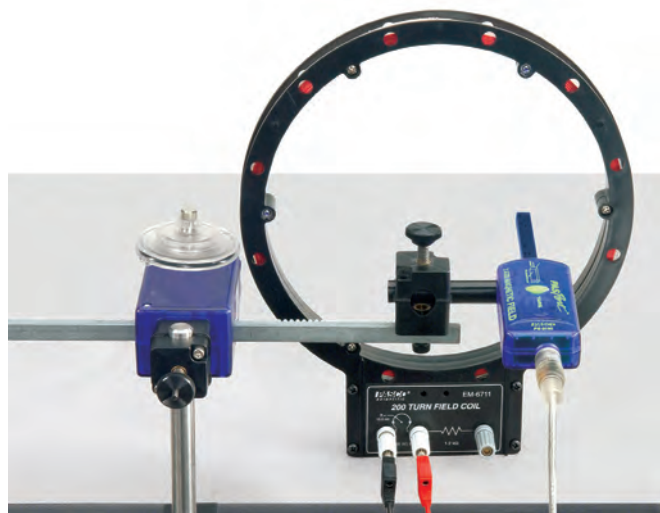
Range: ± 1000 gauss

Resolution: 0.01 gauss at 10 Hz

Accuracy: 5% of reading at 25°C (after four minute warm-up and Tare using Zero Gauss Chamber)

Maximum Sample Rate: 1000 Hz

Repeatability: 0.05%



Magnetic field is measured from the center out to twice the radius of the coil. The angle of the resultant field is calculated.

Order Information

PASPORT 2-Axis Magnetic Field Sensor	PS-2162
Recommended:	
Zero Gauss Chamber	EM-8652
Linear Motion Accessory	CI-6688A p. 35

PASPORT Dual Pressure Sensor

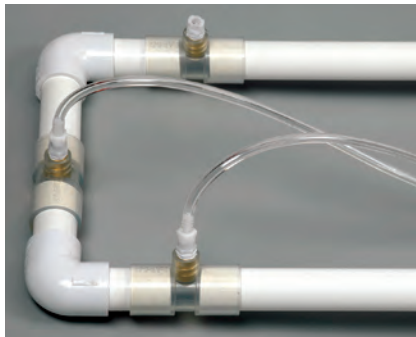
PS-2181



The Dual Pressure Sensor is capable of reading two absolute pressures, one gauge pressure, or one differential pressure. Dynamic variable over-sampling automatically reduces the measurement noise at low sampling rates. Sample rates up to 1000 Hz make studies of both transient and steady-state pressure possible. Includes quick-connect tubing.

Applications:

- Measure pressure in Heat Engine (TD-8572A). See page 243.
- Measure pressure drops in pipes



Instrument your pipe network with the Pressure Taps connected to the Dual Pressure Sensor (PS-2181).

Specifications:

Maximum Sample Rate: 1000 Hz

Absolute Pressure: 0 to 200 kPa, 0.01 kPa resolution at 10 Hz and 1 kPa repeatability (displays pressure in kPa, N/m², and psi)

Differential Pressure: ± 100 kPa, 0.01 kPa resolution at 10 Hz and 1 kPa repeatability (displays pressure in kPa, N/m², and psi)

Order Information

PASPORT Dual Pressure
Sensor.....PS-2181

Pressure Taps (set of 5)

ME-2224A



Order Information

Pressure Taps (set of 5)..... ME-2224A

General Flow Sensor

PS-2222

The General Flow Sensor determines the fluid velocity of air or water by measuring the difference in pressure between the two input tubes. The Venturi Tube or Pitot Tube must be connected to the General Flow Sensor to collect data. The type of fluid (air or water) being used is selected using PASCO software.

Applications:

- The Venturi Tube is used in a pipe network carrying water or air.
- The Pitot Tube is used in an open water channel or air.

Specifications:

Pressure Range: 0 to 50 kPa

Pressure Accuracy: $\pm 2.5\%$ of Full Scale (0 to 85°C)

Resolution: 0.2% of Full Scale

Venturi Range: 0 to 84 gpm (water);
0 to 773 gpm (air)

Venturi Accuracy: ± 2 gpm (water);
 ± 2.5 cf/min (air)

Pitot Range: 0 to 9.98 m/s (water);
0 to 92.1 m/s (air)



Venturi Tube

ME-2220

The Venturi Tube is made of clear PVC so the water can be seen flowing through it. It has a constriction and two pressure ports with tubing attached. The Venturi Tube is connected to the General Flow Sensor by the matching couplers. The General Flow Sensor measures the difference in fluid pressure between the two different cross-sectional areas and the software does a calculation to convert this pressure difference into a velocity or volumetric flow rate. The Venturi Tube slip joints are designed to be glued into any 3/4" PVC pipe network.



Pitot Tube

ME-2221

The Pitot Tube is designed to be placed in the air flow or water flowing in a channel. The General Flow Sensor, connected to the Pitot Tube, measures the pressure difference between the fluid inlet and the static side taps of the Pitot Tube and the software calculates the fluid velocity from the pressure difference.



See pages 198-199 for
more applications.

Order Information

General Flow Sensor with Venturi Tube.....PS-2225
General Flow Sensor with Pitot TubePS-2226
Required:
PASPORT Interface..... p. 18-19
PASCO Capstone Software p. 8-11
Also available separately:
General Flow SensorPS-2222
Venturi Tube.....ME-2220
Pitot Tube.....ME-2221

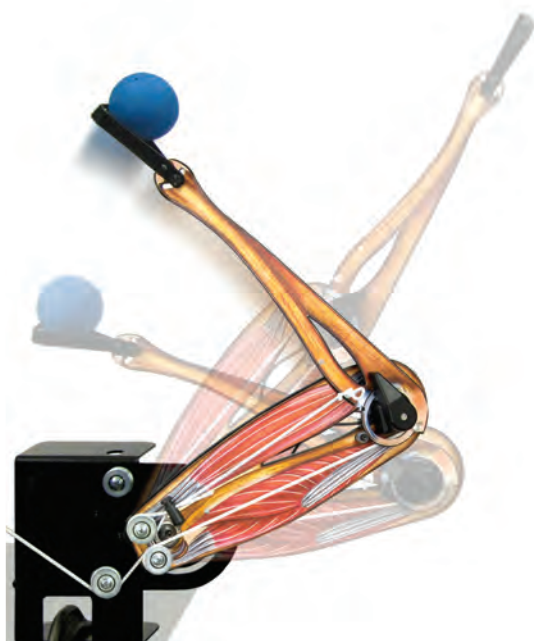
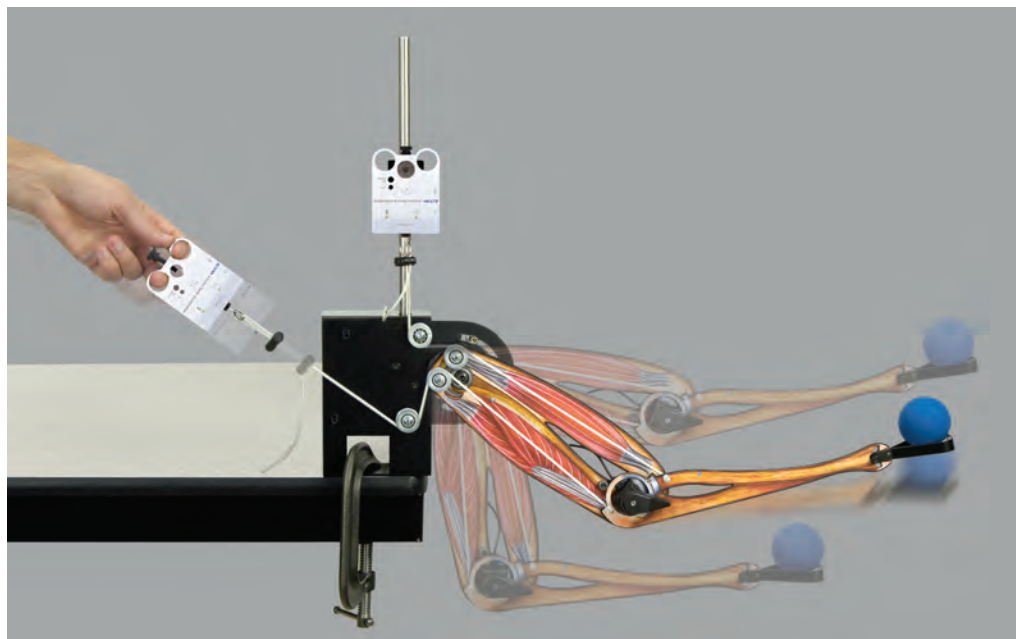
Human Arm Model

PS-2611

- ▶ Working model of the human arm
- ▶ Associate tricep/bicep muscle action with arm motion
- ▶ Measure torque resulting from lifting weights
- ▶ Actually throws a ball

The Human Arm Model simulates the muscles and motion of an actual human arm. Students pull on the cord with a Force Sensor to activate the arm motion. Changes in position are measured at the shoulder and elbow using the two built-in potentiometers and the included Angle Sensor (PS-2139). From this information, the torque applied when lifting an object can be determined. Students may also evaluate the work done by the arm when throwing a ball and the resulting kinetic energy delivered to the ball.

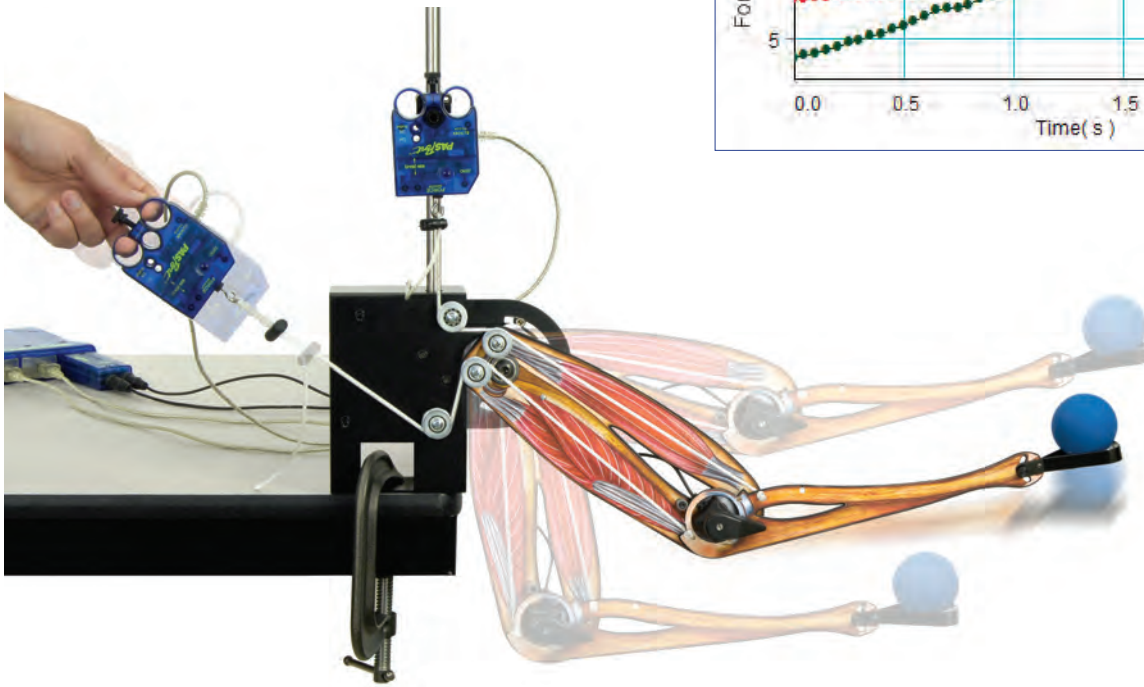
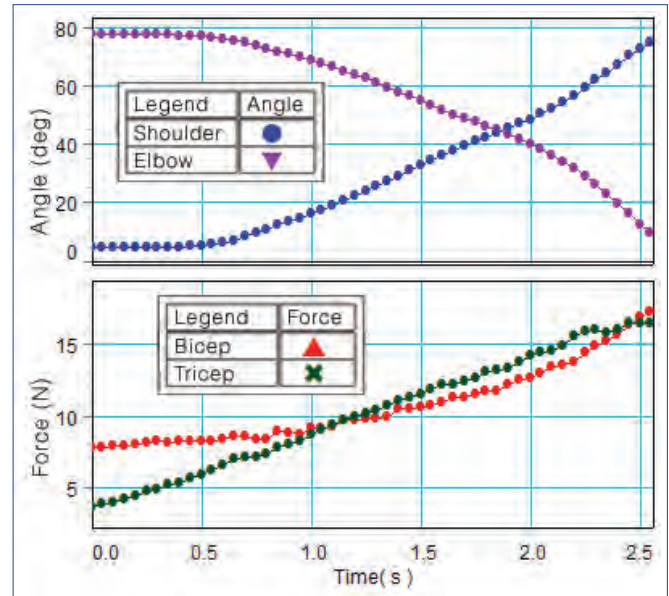
The Arm can perform many types of motion such as extending and lifting an object, curling, or throwing a ball overhand. Different arm muscles are activated depending on which pulleys are selected. Static force measurements can also be made to see how the muscle tension changes at various arm positions.



Features:

- ▶ Actually Throws a Ball
- ▶ Measure Torque Resulting from Lifting Weights
- ▶ Associate Triceps/Biceps Muscle Action with Arm Motion
- ▶ Working Model of the Human Arm

Angles and Forces During Extension: The upper graph shows the angles of the elbow (violet trace) and the shoulder (blue) as the arm is extended. Shown in the lower graph, the bicep tension (red) has little change at first and then rises sharply as the arm reaches out, while the tricep tension (green) rises steadily.



Includes:

- Human Arm Model
- Angle Sensor
- Removable Mass
- Cord & Cord Locks
- Mounting Bracket with Rod
- Force Sensor Mounting Rod
- Rubber Ball

Developed in cooperation with Nancy Beverly, Associate Professor of Physics at Mercy College, Dobbs Ferry, New York.

Order Information

Human Arm Model	PS-2611
Human Arm Model Without Sensors	ME-6807A
Required for force measurement:	
Wireless Force Acceleration Sensor.....	PS-3202 p. 55

SPARK LXi2

Datalogger

PS-3600B

Built for student use both indoors and outdoors.



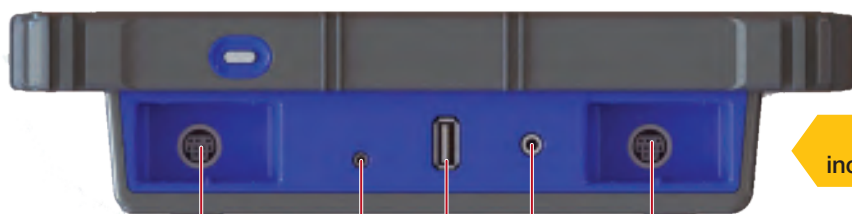
PASPORT sensors connect directly to the LXi2.

SPARK LXi2
PS-3600B

Rugged and rechargeable, the SPARK LXi2 is a handheld datalogger that lets students collect and display sensor data, generate graphs, and analyze results.

Features:

- ▶ 8-hour battery life (standard use)
- ▶ Ruggedized, water resistant case for use indoors and outdoors
- ▶ 8" full-color capacitive touchscreen (1280 x 800 pixels)
- ▶ Simultaneously connects up to 5 PASCO Wireless Sensors
- ▶ Includes 2 PASPORT ports
- ▶ Includes Voltage Probe and port
- ▶ Includes Fast Response Temperature Probe and port
- ▶ Internal GPS, accelerometer, microphone, speakers/line out, and front camera
- ▶ Supports an additional five PASPORT sensors when used with the AirLink, SPARKlink Air, or 550 Universal Interface
- ▶ **Installed software:** SPARKvue®, MatchGraph!, and Spectrometry
- ▶ Android operating system
- ▶ Wi-Fi, Bluetooth®, and USB connections
- ▶ **Tools for data export:** graphs, files, and images



PASPORT
Sensor Port

Voltage Port

USB Port
for Charging

Temperature Port

PASPORT
Sensor Port

The LXi2 also has built-in ports for the included temperature and voltage probes.



Simultaneously connect up to five PASCO Wireless Sensors.



Order Information

SPARK LXi2 Datalogger PS-3600B

SPARK LX AIR

Datalogger

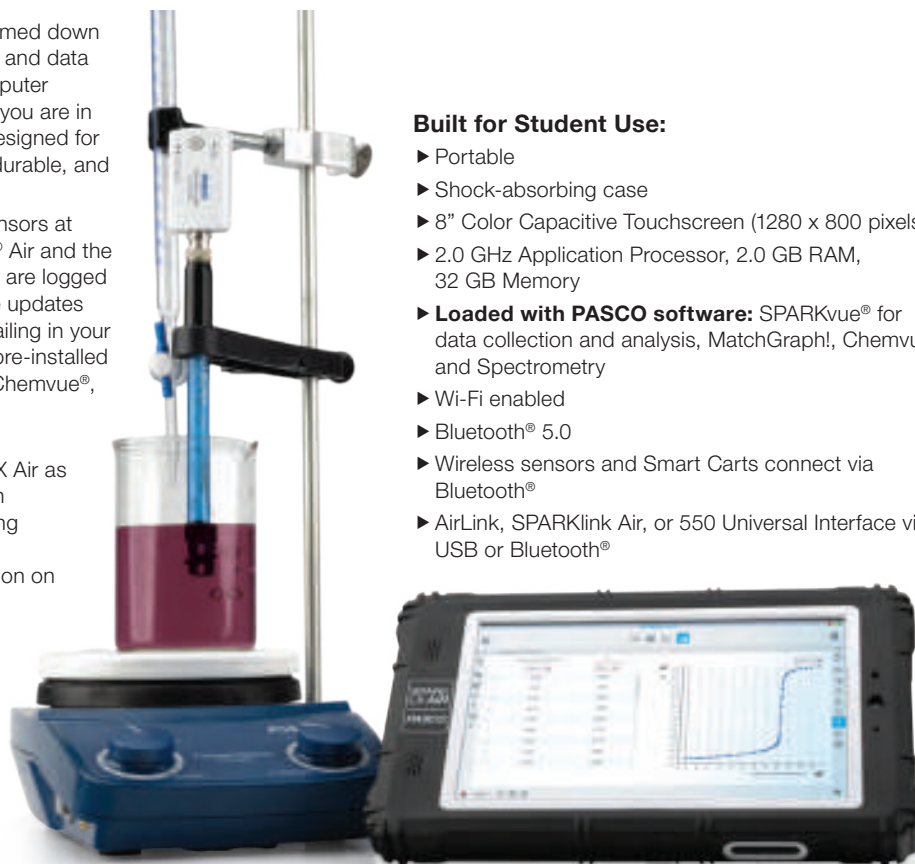
PS-3620

The SPARK LX Air Datalogger is PASCO's slimmed down all-in-one device for data logging, data display, and data analysis. Don't risk damaging your school computer during hands-on experiments! With the LX Air, you are in control of the technology in your classroom. Designed for a wet-lab environment, the LX Air is portable, durable, and splash-proof.

The LX Air can connect to up to 5 Wireless Sensors at once. It is also compatible with the SPARKlink® Air and the 550 Universal Interface. Make sure the devices are logged on to local internet to enjoy automatic software updates and annual student data purging for smooth-sailing in your classroom. The units come ready-to-use with pre-installed data logging software, including SPARKvue®, Chemvue®, Spectrometry, and MatchGraph!

We kept your institution's cyber-security and IT department in mind when we developed the LX Air as a closed environment. Gone are the days when students sneak onto internet browsing or playing games on school-owned devices. The LX Air eliminates distractions and focuses their attention on collecting data and other investigation tasks.

Assigned lab homework but need to keep the LX Air at school? It's easy to export data via USB drives, USB-provided connection cable, Bluetooth sharing or via email to thumb drives, external hard drives, laptops, smartphones and email.



Built for Student Use:

- Portable
- Shock-absorbing case
- 8" Color Capacitive Touchscreen (1280 x 800 pixels)
- 2.0 GHz Application Processor, 2.0 GB RAM, 32 GB Memory
- **Loaded with PASCO software:** SPARKvue® for data collection and analysis, MatchGraph!, Chemvue and Spectrometry
- Wi-Fi enabled
- Bluetooth® 5.0
- Wireless sensors and Smart Carts connect via Bluetooth®
- AirLink, SPARKlink Air, or 550 Universal Interface via USB or Bluetooth®

Specifications:

Application Processor (CPU): 2.0 GHz Quad Core

Screen: 8.00" color capacitive touchscreen, 1280 x 800 px; 16:10 aspect ratio

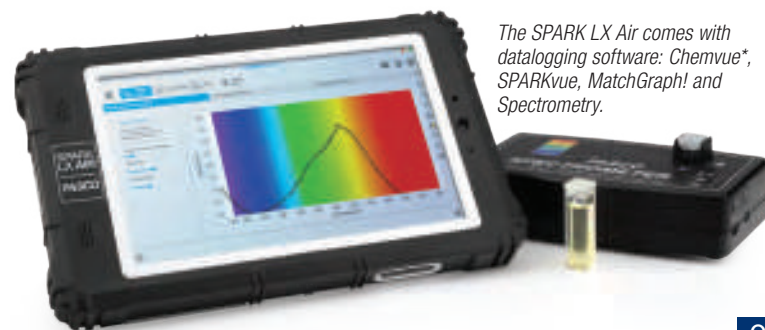
Memory: 32GB eMMC Flash, 2.0 GB DDR4 RAM

Wi-Fi: 802.11a/b/g/n/ac

Bluetooth: 5.0

Connectivity: Wi-Fi, Bluetooth®, USB-C

Battery: LiPo battery up to 8 hours between charges



The SPARK LX Air comes with datalogging software: Chemvue, SPARKvue, MatchGraph! and Spectrometry.*



Includes:

- USB-C connection cable
- Single Port USB Wall Charger (PS-2575A)

Order Information

SPARK LX Air Datalogger.....PS-3620

SPARK LX Air Datalogger with Chemvue*PS-3621

*For information on Chemvue software, visit pasco.com/chemvue

AirLink and PASPORT Adapters

AirLink Interface

PS-3200



The AirLink Interface connects PASPORT sensors to a Mac or Windows computer, Chromebook, iPad, tablet, or smartphone via Bluetooth or USB connection. The USB cable is included for charging ideally through a usb charging block and data connection to your computer.

Includes: USB cable

Specifications:

Approximate Mass: 59 g

Connectivity: USB and Bluetooth 5.2

USB Connector Type: Micro USB

Bluetooth Range: 30 m (unobstructed)

Logging: No

Battery Type: Rechargeable LiPo

Order Information

AirLink Interface PS-3200

PASPORT Digital Adapter

PS-2159

- ▶ Required for counting and timing sensors
- ▶ Allows digital ScienceWorkshop sensors to be used with PASPORT interfaces



The Digital Adapter is required when photogates, timing and counting sensors are used with any PASPORT interface. Each Digital Adapter accommodates two sensors at once. Each port on the Digital Adapter automatically detects a connection and initiates a selection of pre-configured or user-defined options. Several Digital Adapters can be used simultaneously when required.

Specifications:

Resolution for Counting and Timing Devices: 2 μ s

Resolution for Motion Sensors: 1 μ s

Input: Two 1/4" stereo phone jacks

Order Information

PASPORT Digital Adapter PS-2159

PASPORT Analog Adapter

PS-2158

- ▶ Use your black ScienceWorkshop sensors with blue PASPORT interfaces
- ▶ No need to buy new sensors



Use an Analog Adapter to connect ScienceWorkshop sensors with an 8-pin or 5-pin DIN connector such as:

- Colorimeter (CI-6747)
- Current (CI-6556)
- Force (CI-6537)
- Force, Economy (CI-6746)
- Infrared (CI-6628)
- Light (CI-6504A)
- Light, High-Sensitivity (CI-6604)
- Light, UVA (CI-9784)
- Magnetic Field (CI-6520A)
- Pressure Sensor-Absolute (CI-6532A)
- Sound (CI-6506B)
- Temperature (CI-6605A)
- Temperature, High Accuracy (CI-6525)

Order Information

PASPORT Analog Adapter PS-2158

PASCO Wireless Sensor Family

Our rugged, low-cost Wireless Sensors connect directly to computers, Chromebooks, laptops, tablets, and smartphones, allowing students to spend less time setting up experiments and more time exploring and experiencing the science phenomena.

In Logging Mode, Wireless Sensors store data to their onboard memory for hours, days, weeks or even months at a time without needing to be connected to a computer, tablet, Chromebook or smartphone. When the experiment has concluded, simply connect the sensor to a device running PASCO software and download all the measurements for hassle-free analysis.

Wireless Sensors

3-Axis Acceleration/Altimeter	55
3-Axis Magnetic Field	64
Charge	62
//code.Node	68
//control.Node	68
Current	60
Current Module	60
Force Acceleration	55
Force Platforms (1D & 2D)	56
Geiger Counter	65
Hand Dynamometer	55
Light and Color	63
Magnetic Field	64
Motion Sensor	53
Pressure/Temperature with Display	57
Rotary Motion Sensor	53
Smart Cart	52
Smart Gate	54
Smart Pulley	54
Sound	62
Spectrometer, UV-Vis	66
Spectrometer, Visible	67
Temperature	58
Temperature Link	59
Temperature, Type K	59
Voltage	60
Voltage/Current with Display	61

Wireless Accessories

AirLink	54
Wireless Charging Stations	87
Wireless Sensor Packs	87
Wireless Storage Solutions	87



Smart Cart

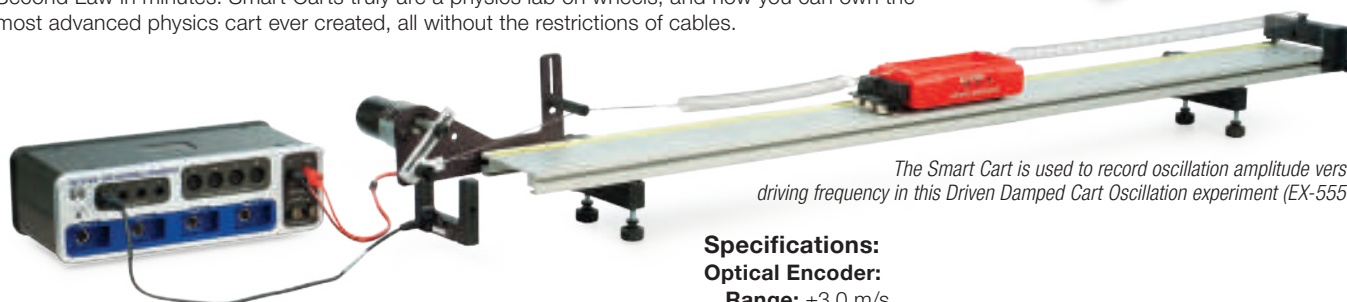
Smart Cart

ME-1240 (red) ME-1241 (blue)

- ▶ Your mechanics lab on wheels
- ▶ Built-in force sensor (± 100 N)
- ▶ Built-in wireless force, position, and acceleration sensors
- ▶ Built-in 3-D acceleration sensor (± 16 g)
- ▶ Optical encoder measures motion
- ▶ Data is transmitted wirelessly
- ▶ No interface required
- ▶ Rechargeable lithium-polymer battery

The patented Smart Cart is the ultimate tool for studying kinematics, dynamics, Newton's Laws, and more. It is based on a durable ABS body with nearly frictionless wheels, just like our high quality PAScars. Now, we've added built-in sensors that measure force, position, velocity, and acceleration. The versatile Smart Cart can collect measurements on or off a track and transmit the data wirelessly over Bluetooth. In essence, it is a wireless dynamics cart that combines all the necessary sensors, without requiring any additional hardware.

Smart Carts are ideal for studying mechanics topics, such as kinematics and dynamics. The built-in load cells enable two Smart Carts to visually demonstrate Newton's Third Law with ease. Additionally, built-in sensors for force and acceleration enable students to investigate Newton's Second Law in minutes. Smart Carts truly are a physics lab on wheels, and now you can own the most advanced physics cart ever created, all without the restrictions of cables.



The Smart Cart is used to record oscillation amplitude versus driving frequency in this Driven Damped Cart Oscillation experiment (EX-5551).

Features:

- ▶ Built-in ± 100 N force sensor
- ▶ 3-axis accelerometer
- ▶ 3-axis rotational velocity sensor
- ▶ Bluetooth® connectivity
- ▶ Rechargeable battery
- ▶ Motion encoder measures position and velocity on or off the track
- ▶ Magnetic bumper for force sensor
- ▶ 3-position plunger
- ▶ Mass tray
- ▶ Velcro® tabs
- ▶ Force sensor hook and rubber bumper

Applications:

- ▶ Kinematics
- ▶ Newton's Laws
- ▶ Impulse
- ▶ Conservation of Momentum
- ▶ Elastic and Inelastic Collisions
- ▶ Conservation of Energy
- ▶ Simple Harmonic Oscillators
- ▶ Magnetic damping
- ▶ Determining g using acceleration on an incline
- ▶ And much more!

Specifications:

Optical Encoder:

- Range:** ± 3.0 m/s
- Resolution:** ± 0.2 mm
- Maximum Sample Rate:** 500 Hz

Accelerometer:

- Range:** ± 16 g
- Accuracy:** ± 0.2 m/s² at 9.8 m/s²
- Maximum Sample Rate:** 500 Hz

Force Sensor:

- Range:** ± 100 N
- Resolution:** 0.1 N
- Accuracy:** $\pm 1.0\%$
- Maximum Sampling Rate:** 2 kHz

Gyro Sensor:

- Range:** ± 245 deg/second
- Maximum Sample Rate:** 500 Hz

Mass (without accessories): 250 g

Patent No.: 10481173

Connectivity: USB and Bluetooth 5.2

Logging: No

Battery Type: Rechargeable LiPo

Includes:

- Hook
- Rubber bumper
- Magnetic bumper
- USB cable for charging

U.S. Patent Number
10,481,173



Order Information

Smart Cart (Red)	ME-1240
Smart Cart (Blue)	ME-1241

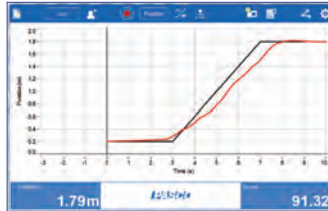
Wireless Motion Sensor

PS-3219

The Wireless Motion Sensor connects via Bluetooth or USB to your device, and uses ultrasound to measure the position, velocity, and acceleration of objects. This enables students to take turns measuring themselves, while the class observes their motion materializing as a graph in real time. The sensor can detect objects ranging from 15 cm to 4.0 m away, and without cables to get in the way, students can explore handheld and ceiling-mounted applications.



The Wireless Motion Sensor works with our free MatchGraph! software. It is an ideal way to teach the concepts of motion graphing, interpreting graphs, and rate of change or slope.



Specifications:

Range: 0.15 to 4 m**Resolution:** 1 mm**Maximum Sample Rate:** 250 Hz**Transducer Rotation Range:** 180°**Connectivity:** USB and Bluetooth 5.2**Logging:** No**Battery Type:**

Rechargeable LiPo

Order Information

Wireless Motion SensorPS-3219

Recommended:

MatchGraph! Software.....p. 14

Also available:

Wireless Motion Sensor Pack*.....PS-3337

* Includes 8 sensors in a Gratnells® storage tray with custom insert.

Motion Sensor Guard

SE-7256

Use this wire guard to protect the Motion Sensor when dropping objects from above.



Order Information

Motion Sensor GuardSE-7256

Motion Sensor Bracket

PS-2546

This magnetic bracket allows a Motion Sensor to be easily hung from a drop ceiling. Simply screw the bracket into the 1/4"-20" threads on the sensor and use the included adjustment nut to hold the sensor in the desired orientation.



The bracket can also be used to hold the Motion Sensor on vertical surfaces such as filing cabinets and magnetic whiteboards.

Order Information

Motion Sensor Bracket.....PS-2546

Cart Adapter Accessory

ME-6743

The Cart Adapter Accessory allows the Motion Sensor and many other sensors to be mounted to a Dynamics Cart or a PAScar.



The adjustment knob on the bracket allows the Motion Sensor to face any direction.

Order Information

Cart Adapter Accessory.....ME-6743

Wireless Rotary Motion Sensor

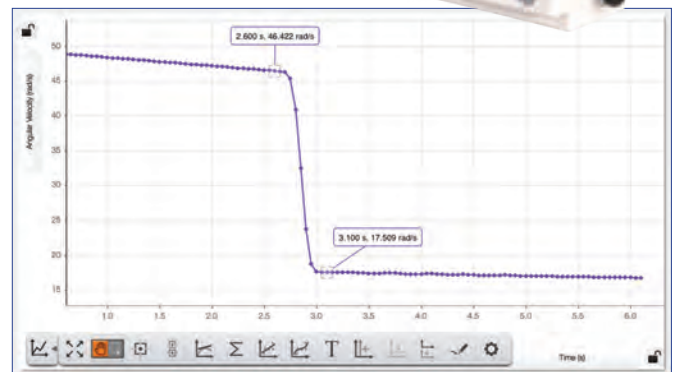
PS-3220



The Wireless Rotary Motion Sensor measures angle, angular velocity, and angular acceleration, as well as their linear equivalents. The included three-step pulley can be rotated at different rates of acceleration to apply various torques. Use the included rod-mounting holes to position the sensor for different experiments. The Wireless Rotary Motion Sensor connects directly to your devices via Bluetooth or USB.



Show that angular momentum is conserved. The Wireless Rotary Motion Sensor records the angular velocity as a ring is dropped on a spinning disk.



Specifications:

Angular Resolution: 0.18°**Linear Resolution:** 0.0157 mm (with 10 mm pulley radius)**Three-Step Pulley:** 10, 29, and 48 mm diameter**Shaft Diameter:** 6.35 mm**Maximum Rotation Rate:** 30 rev/s**Optical Encoder:** 2000 divisions/rev, bidirectional**Connectivity:** USB and Bluetooth 5.2**Logging:** Yes**Battery Type:** Rechargeable LiPo

Order Information

Wireless Rotary Motion SensorPS-3220

Shown in use with:

Rotational Inertia Accessory.....ME-3420 p. 194

Physics Sensors

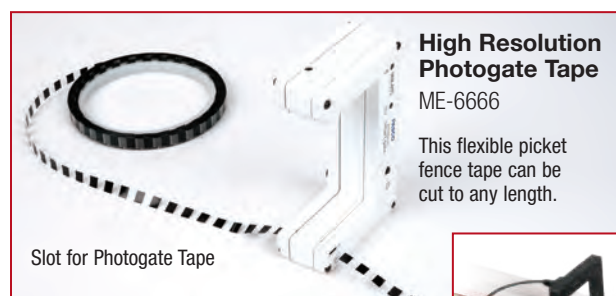
Wireless Smart Gate

PS-3225

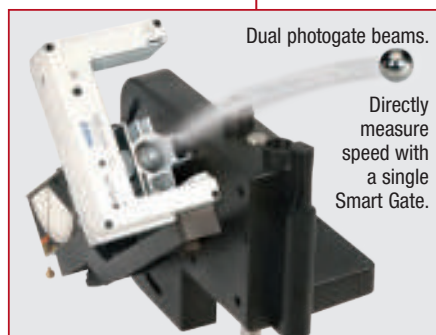
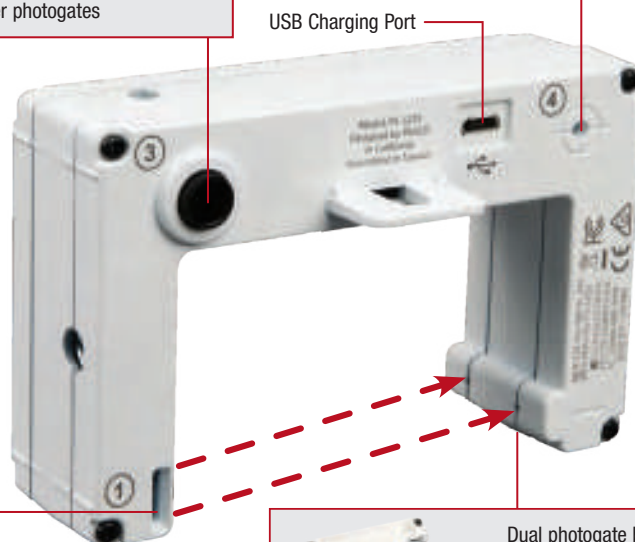
- Dual photogate beams
- Laser switch
- Photogate tape slot
- Auxiliary photogate/Time-of-Flight port
- USB and Bluetooth®
- Rechargeable

The Wireless Smart Gate is more than just a photogate. It has dual photogate beams spaced 1.5 cm apart to accurately measure speed. When used with a laser, students can use the built-in laser switch to time objects that are too large to fit through the photogate beams. It also includes a photogate tape slot for measuring the movement of objects and an auxiliary port for adding another photogate head or the Time-of-Flight Accessory.

We do not recommend using two Wireless Smart Gates in the same experiment unless the measured times are relatively long (greater than one-half of a second) since synchronization is limited to 2 ms.

**Specifications:****Gate Separation:** 1.5 cm**Timing Resolution:** 3 microseconds**Minimum Block Time:** 1.5 ms**Beam Wavelength:** 940 nm**Gate Inside Width:** 7.2 cm**Dimensions (L x W x H):**

10.5 cm x 7.0 cm x 3.0 cm

Product Approximate mass: 90 g**Connectivity:** USB and Bluetooth 5.2**Logging:** No**Battery Type:** Rechargeable LiPo**Order Information**

Photogate Wireless Smart Gate PS-3225
 Recommended:
 Time-of-Flight Accessory ME-6810A
 Photogate Tape, High Resolution (30 m) ME-6666

Wireless Smart Gate Dynamics System

PS-3703

When used with a computer for data recording, display, and analysis, this photogate timing system provides a wide range of time, speed, and velocity measurements. The photogates mount to the Dynamics Track using the provided brackets. The provided Picket Fences mount directly to the Dynamics Carts.

Includes:

- Wireless Smart Gate PS-3225
- Photogate Head ME-9498A
- Photogate Brackets (2 pack) ME-9806
- Cart Picket Fences (2 pack) ME-9804

**Order Information**

Wireless Smart Gate Dynamics System PS-3703

Wireless Smart Pulley

PS-3704

The Wireless Smart Pulley attaches directly to the Wireless Smart Gate, providing a simple, low-friction system to measure position, velocity and acceleration. Additionally, with the pulley removed, the photogate can be used to perform standard photogate experiments.

Includes:

- Wireless Smart Gate: PS-3225
- Super Pulley: ME-9450A
- Super Pulley Rod

**Order Information**

Wireless Smart Pulley PS-3704

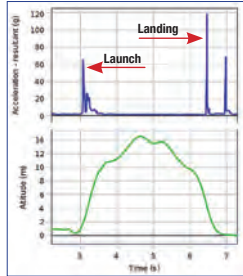
Wireless Acceleration/Altimeter

PS-3223

- ▶ 3-axis accelerometer
- ▶ 3-axis gyroscope
- ▶ Altimeter
- ▶ Rubberized case



The Wireless 3-Axis Acceleration/Altimeter can remotely log acceleration in three dimensions and altitude, making it ideal for recording roller coaster rides.



The Wireless 3-Axis Acceleration/Altimeter is launched by a stretched rubber band that is connected to one of the many attachment holes in the rubberized case. The graph shows the resultant acceleration (measured in g's) and the altitude for the four-second flight.



Specifications:

Low-g Accelerometer:

- Range:** ± 16 g
- Resolution:** 0.002 g at 20 Hz sample rate
- Accuracy:** ± 0.04 g
- Maximum Sample Rate:** 5 kHz

High-g Accelerometer:

- Ranges:** ± 100 g, ± 200 g, ± 400 g
- Resolution:** 0.04 g (@ ± 100 g) at 20 Hz sample rate
- Accuracy:** ± 1 g (@ ± 100 g)
- Maximum Sample Rate:** 5 kHz

Altimeter:

- Range:** -1.8 km to 9.5 km
- Resolution:** 10 cm
- Maximum Sample Rate:** 200 Hz

Gyroscope:

- Range:** ± 34.9 rad/s
- Accuracy:** ± 0.02 rad/s
- Maximum Sample Rate:** 1 kHz

Mass: 35.5 g

Dimensions: 8 cm x 4 cm x 2 cm

Connectivity: Bluetooth 5.2

Logging: Yes

Battery Type: Coin Cell

Order Information

Wireless Acceleration/
Altimeter PS-3223

Wireless Force Acceleration Sensor

PS-3202

- ▶ Eliminates wires
- ▶ Measures force, acceleration, and rotation



Capable of simultaneously measuring force, acceleration, and rotational velocity, this sensor is ideal for experiments involving rotating platforms, moving carts, spring oscillations, collisions, and impulse. The wireless design offers improved measurement accuracy by eliminating cords that affect data collection. Students can use the finger-holes for handheld applications, or mount it onto a cart or rod for more complex experiments.

Features:

- ▶ ± 50 N force sensor
- ▶ 3-axis accelerometer (± 16 g)
- ▶ 3-axis gyroscope
- ▶ Finger-holes
- ▶ Built-in rod clamp

Specifications:

Force Sensor:

- Range:** ± 50 N
- Resolution:** 0.03 N
- Accuracy:** 0.1 N
- Maximum Sample Rate:** 1000 Hz

Accelerometer:

- Range:** ± 16 g
- Accuracy:** ± 0.2 m/s² (at 9.8 m/s²)
- Maximum Sample Rate:** 500 Hz

Gyro Sensor:

- Range:** ± 2000 °/s
- Maximum Sample Rate:** 500 Hz

Connectivity: USB and Bluetooth 5.2

Logging: Yes

Battery Type: Rechargeable LiPo



Includes:

- Hook attachment
- Rubber bumper attachment
- Cart/bracket thumbscrew
- Rechargeable lithium-polymer battery
- USB cable

Order Information

Wireless Force
Acceleration Sensor PS-3202

Also available:

Wireless Force Acceleration
Sensor Pack* PS-3339

* Includes 8 sensors in a Gratnells® storage tray with custom insert.

Wireless Hand Dynamometer

PS-3253

NEW



The Wireless Hand Dynamometer combines a force load cell, 3 axis accelerometer, and gyrometer to analyze how grip strength changes through complex, swings, hits or jabs. Grip and pinch sensor on same load cell so are additive. Plot force and stamina as muscles fatigue.

Combine with other physiology sensors to study correlate strength to breathing, ECG, heart rate, or blood pressure.

Specifications:

Force:

Range: 0-630 N (warning at 600N)

Accuracy: 0.01N

Precision: ± 0.1 N

Rotation Range: ± 2000 °/s (± 637 rad/s)

Accelerometer:

Range: ± 16 g

Accuracy: ± 0.2 m/s²

Sample Rate: 500 hz

Connectivity: USB & Bluetooth 5.2

Logging: Yes

Battery: Li Po



test and compare grip through complex motion.

Order Information

Wireless Hand
Dynamometer PS-3253

Physics Sensors

Wireless Force Platform

PS-3229

The Wireless Force Platform builds on the success of our PASPORT Force Platform, offering users the same reliable performance with enhanced durability and a convenient, wireless connection.



The new design features a sturdy, glass-filled nylon platform and four supporting force beams that measure the forces acting normal to the platform's surface. Along the bottom of the platform are four adjustable feet that make leveling quick and easy, while also ensuring stability between the force beams and the surface below. Students can measure the force applied to each beam independently or the overall resultant force acting on the surface of the platform (up to 5200 N). With its new wireless design, the Wireless Force Platform is easier to use than ever, providing both special flexibility and custom sample rates for high speed sampling over Bluetooth Low Energy (up to 10 kHz).

The Wireless Force Platform can be used to measure the static weight of a structure or person, the dynamic vertical forces created when moving or jumping, or the forces associated with the impact of falling objects. Simply place the platform on a floor or tabletop to measure vertical force, or mount it to a wall to measure horizontal force.

Applications:

- ▶ Measure impulse and maximum force
- ▶ Determine hang time by jumping from and landing on the platform
- ▶ Measure the normal (vertical) force acting on a person riding an elevator
- ▶ Use two Force Platforms to investigate Newton's Third Law
- ▶ Use a Motion Sensor and a ball to compare the impulse and change in momentum as the ball collides with the platform

Features:

- ▶ Improved ruggedized design with increased maximum force range (up to 5200 N, resultant)
- ▶ Wide surface for jumping, standing, and walking
- ▶ Mechanical force over-limit protection
- ▶ Burst sampling option for high-speed wireless data collection
- ▶ Built-in handle for easy transport

Specifications:**Range:** -1320 N to 5280 N (resultant)**Resolution:** 0.2 N**Maximum Sample Rate:** 10 kHz**Surface Dimensions:** 35 cm x 35 cm**Force Over-Limit Protection:** -500 N to 2000 N per beam**Connectivity:** USB and Bluetooth 5.2**Logging:** No**Battery Type:** Rechargeable LiPo**Order Information**

Wireless Force Platform PS-3229

Wireless 2-Axis Force Platform

PS-3230

Building on the success of the PASPORT 2-Axis Force Platform, the Wireless 2-Axis Force Platform offers users the same reliable performance with enhanced durability and a convenient, wireless connection. The new design features a sturdy, glass-filled nylon platform with a sheet metal top and five force beams. Four vertical beams measure forces acting normal to the platform's surface, while a fifth beam, attached to the movable sheet metal top, measures forces acting parallel to the platform's surface. The platform also includes four adjustable feet that make leveling quick and easy, while ensuring a stable connection is made between the force beams and the surface below.



With its new wireless design, the Wireless 2-Axis Force Platform is easier to use than ever, providing both special flexibility and custom sample rates for high-speed sampling over Bluetooth Low Energy (up to 10 kHz). Students can measure the force applied to each beam independently or the overall normal force acting on the platform, with measurements up to 5200 N. They can also measure the normal and parallel forces acting on the platform simultaneously. Applications

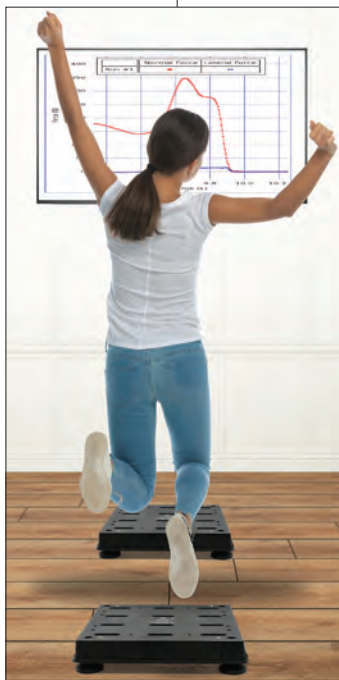
include determining the static weight of a structure or person, measuring forces associated with the impacts of falling objects, and determining the dynamic vertical and parallel forces that arise when moving or jumping. Simply place the platform on a floor or tabletop to measure vertical force, or mount it to a wall to measure horizontal force.

Applications:

- ▶ Determine hang time by jumping from and landing on the platform
- ▶ Use two Force Platforms to investigate Newton's Third Law
- ▶ Measure impulse and maximum force
- ▶ Measure the normal force acting on a person riding an elevator
- ▶ Use a Motion Sensor and a ball to compare the impulse and change in momentum as the ball collides with the platform
- ▶ Measure the sideways force during a broad jump
- ▶ Measure the normal and parallel forces on a wall as a ladder leans against the wall
- ▶ Measure the normal and parallel forces as a person walks or runs across the platform
- ▶ Pull an object across the platform and measure the normal and frictional forces

Specifications:**Normal Force Range:** -1320 N to 5280 N (resultant)**Parallel Force Range:** $\pm 1,300$ N**Resolution:** 0.2 N**Maximum Sample Rate:** 10 kHz**Product Force Over-Limit Protection:** -500N to 2000 N per vertical beam; $\pm 2,000$ N parallel beam**Dimensions:** 35 x 35 x 7.1 cm**Connectivity:** USB and Bluetooth 5.2**Logging:** No**Battery Type:** Rechargeable LiPo**Order Information**

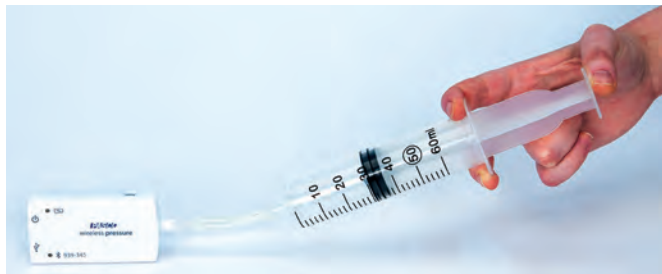
Wireless 2-Axis Force Platform PS-3230



Wireless Pressure Sensor

PS-3203

The Wireless Pressure Sensor allows students to easily collect accurate gas pressure data for a wide range of applications. Included is a 60cc syringe, tubing, and connectors that facilitate experiments such as Boyle's Law or measuring pinch-grip strength. Within PASCO's software, students can easily select their desired units from a list containing kPa, mmHg, inHg, mbar, psi, atm, and torr.



Make accurate and consistent measurements of gas pressure, regardless of ambient conditions. Study the Empirical Gas Laws.

Specifications:

Range: 0 to 400 kPa

Resolution: 0.1 kPa

Accuracy: ± 2 kPa

Maximum Sample Rate: 1000 Hz

Connectivity: USB and Bluetooth 5.2

Logging: Yes

Battery Type: Rechargeable LiPo

Includes:

- Polyurethane Plastic Tubing, 2 ft
- In-Line Tubing Connector
- Male Barbed Luer Locks (2)
- Female Barbed Luer Lock
- 60 cc Syringe
- Micro USB Cable (PS-3584)
- #6 one hole Rubber Stopper

Order Information

Wireless Pressure SensorPS-3203

Also available:

Wireless Pressure Sensor Pack*PS-3333

* Includes 8 sensors in a Grattells® storage tray with custom insert.

Wireless Absolute Pressure-Temperature Sensor

NEW

PS-4257

The Wireless Absolute Pressure-Temperature Sensor is built to work with the Ideal Gas Law Apparatus (TD-8596A), Absolute Zero Sphere (TD-8595), and Heat Engine Apparatus (TD-8572) to monitor pressure changes with increase or decrease of temperature. Great to display Boyles, Charles, Amonton's or the ideal gas laws. Helps gather the evidence to calculate work done by a gas. Can also show comparison of vapor pressure to temperatures of the exterior of sealed containers of liquids. Sensor reaches up to 7 atm pressure!



Specifications:

Compatible Temp Probes: Skin/Surface (PS-2131 incl), Fast Response (PS-2135), Stainless Steel PS-2153)

Temperature (quick response):

Range: -30 to 105 °C

Accuracy: ± 0.5 °C

Precision: ± 0.05 °C

Max Sample Rate: 10 Hz

Pressure:

Range: 0 to 740 kPa

Accuracy: ± 2 kPa or 2% of reading at higher pressures

Precision: 0.01 kPa

Max Sample Rate: 1000 Hz

Connector: Female Luer Lock

Communication: USB C, Bluetooth 5.2

Logging: Yes

Max Stored Data Points: 22,000

Battery Type: Rechargeable LiPo

Order Information

Wireless Absolute Pressure-Temperature SensorPS-4257

Physics Sensors

Wireless Temperature Sensor

PS-3201

Welcome to the modern thermometer. The Wireless Temperature Sensor transmits live data and allows students to continuously monitor, log, and plot temperature measurements on nearly any device. This durable, wireless sensor features a stainless steel probe for the most demanding of applications, as well as a battery that lasts over a year*. It can be used in a wide array of experiments and activities because it measures small, but significant temperature changes produced by chemical reactions, convection currents, and even skin temperatures.



Features:

- ▶ Simply pair and go, no cables or adapters to manage
- ▶ Variable sampling rate for capturing small, fast changes or experiments that run for hours, days, or weeks
- ▶ Bluetooth wireless connectivity and long-lasting coin cell battery
- ▶ Logs temperature data directly onto the sensor for long-term experiments
- ▶ Dust, dirt, and sand-proof and water resistant (IP-X7 certified)



The versatile Wireless Temperature Sensor works well, both in the lab and outdoors.

Specifications:

Range: -40°C to 125°C

Resolution: 0.01°C

Accuracy: $\pm 0.5^\circ\text{C}$

Maximum Sample Rate: 10 Hz

Connectivity: Bluetooth 5.2

Logging: Yes

Battery Type: Coin Cell

Order Information

Wireless Temperature Sensor.....PS-3201

Also available:

Wireless Temperature Sensor Pack*.....PS-3330

* Includes 8 sensors in a Grattells® storage tray with custom insert.

Wireless Temperature Sensor
with Display

PS-4201



Our modern thermometer just keeps getting better. We've added a bright organic light-emitting diode (OLED) display on the sensor for users who want the ability to see instant data readings without the need for additional software, even in bright outdoor explorations. This sensor still provides the option for quality wireless temperature data transmitted live for continuously monitoring, logging, and plotting temperature measurements on nearly any device. When lab-time ends but the experiment continues, students can set the sensor to log data autonomously for days, weeks, or months, then download that data for analysis later. This durable, wireless sensor features a stainless steel probe for the most demanding of applications, and it contains a rechargeable battery via a standard USB C cable. It can be used in a wide array of experiments and activities because it measures small but significant temperature changes produced by chemical reactions, convection currents, and even skin temperatures.

Features:

- ▶ Simply charge, pair and go, no cables or adapters to manage
- ▶ Variable sampling rate for capturing small, fast changes or experiments that run for hours, days, or weeks
- ▶ Bluetooth® connectivity and long-lasting rechargeable battery
- ▶ Logs temperature data directly onto the sensor for long-term experiments
- ▶ Dust, dirt, sand and water resistant



Specifications:

Approximate Mass: 42 g

Range: -40 to 125°C

Resolution: 0.01°C

Accuracy: $\pm 0.5^\circ\text{C}$

Maximum Sample Rate: 10 Hz

Splash resistant: IPX4

Probe Material: Corrosion Resistant 316 Stainless Steel

Diameter: 0.19 in (5.0 mm)

Length: 4.7 in (120 mm)

Response Time: 5.1s to reach 63% of value in response to step change in temperature.

Connectivity: Bluetooth 5.2

Logging: Yes

Battery Type: 300 mAh Li ion

Includes:

- Li-ion 300 mAh rechargeable battery

Order Information

Wireless Temperature Sensor with Display.....PS-4201

Wireless Thermocouple

PS-4256

NEW

PASCO's Wireless Thermocouple with Display greatly expands the measurement range of our line of temperature-sensing products. This Thermocouple expands our standard thermometers from -40 to 125 °C now up to -200 to +1400°C. Packaged with a three foot type K thermocouple, its small thermal mass responds quickly to changes in temperature. This is ideal to record the outside surfaces of metal containers with reactions or heat exchange processes. Experiments can be monitored down to temperatures of solutions cooled by commercial freezers (-30°C), dry ice (-78.5°C), or even evaporating liquid nitrogen (-196°C). Students can also use this sensor to measure up to the heat of stove elements, matches, and non-optimized Bunsen burners. Note: An optimal fuel-to-oxygen Bunsen flame can get hot enough to damage the tip of the type K sensor. The tip of the inner blue flame is close to the melting temperature of the solder used in the sensor.

Thermocouple is great for high or low temperatures.

**Specifications:****Range:** - 200 to 1400 °C**Accuracy:** $\pm 2^\circ \text{C}$ **Precision:** 0.1 °C**Maximum Sample Rate:** 10 Hz**Units Available:** °C, °F, K**Connectivity:** USB C, Bluetooth 5.2**Battery Type:** Rechargeable LiPo**Logging:** Yes**Remote Data Logging Storage:** 55,000**Order Information**

Wireless Thermocouple with DisplayPS-4256

Wireless Temperature Sensor Link

PS-3222

- Accepts three types of thermistor temperature probes
- Includes Fast Response Temperature Probe

**Specifications:****Compatible Temperature Probes:** Skin/Surface (PS-2131); Fast Response (PS-2135); Stainless Steel (PS-2153)**Range with included probe:** -35 °C to 135 °C**Resolution:** 0.05 °C**Accuracy:** $\pm 0.5^\circ \text{C}$ **Maximum Sample Rate:** 20 Hz**Connectivity:** USB and Bluetooth 5.2**Jack:** 3.5 mm stereo**Logging:** Yes**Battery Type:** Coin Cell**Battery Life:** >1 year**Includes:**Fast Response
Temperature Probe**Order Information**

Wireless Temperature Sensor LinkPS-3222

Compatible Temperature Probes:

PASPORT Skin/Surface Temperature ProbePS-2131

PASPORT Fast Response Temperature Probe (3 pack)PS-2135

PASPORT Stainless Steel Temperature ProbePS-2153

Temperature Probes**PASPORT Skin/Surface Temperature Probe**

PS-2131

- Flat sensing element ideal for surfaces
- Quickly reaches equilibrium temperature with surface

Range: -10 to +70°C**Order Information**

PASPORT Skin/Surface Temperature ProbePS-2131

PASPORT Fast Response Temperature Probe (3 pack)

PS-2135

- Includes 10 adhesive patches

Range: -30 to +105°C**Order Information**

PASPORT Fast Response Temperature Probe (3 pack)PS-2135

PASPORT Stainless Steel Temperature Probe

PS-2153

Range: -35 to +135°C**Order Information**

PASPORT Stainless Steel Temperature ProbePS-2153

Order Information**All of the probes above require one of the following temperature sensors:*

PASPORT Temperature SensorPS-2125

PASPORT Quad Temperature SensorPS-2143

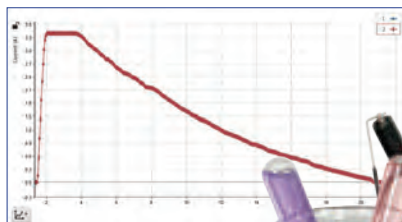
Temperature SensorCI-6605A p. 30

Physics Sensors

Wireless Current Sensor

PS-3212

The Wireless Current Sensor's wide current range enables introductory and advanced explorations of the fundamental concepts of electricity and basic circuits.

**Specifications:****High Current:****Range:** ± 1 A**Resolution:** 0.2mA**Low Current:****Range:** ± 0.1 A**Resolution:** 0.02mA**Input Resistance:** 0.1 Ω **Maximum Sample Rate:** 100 kHz**Connectivity:** USB and Bluetooth 5.2**Logging:** Yes**Battery Type:** Rechargeable LiPo**Includes:**

- Wireless Current Sensor
- USB Cable
- Red, Banana-to-alligator-clip
- Black, Banana-to-alligator-clip

Order Information

Wireless Current Sensor PS-3212

Also available:

Wireless Current Sensor Pack* PS-3336

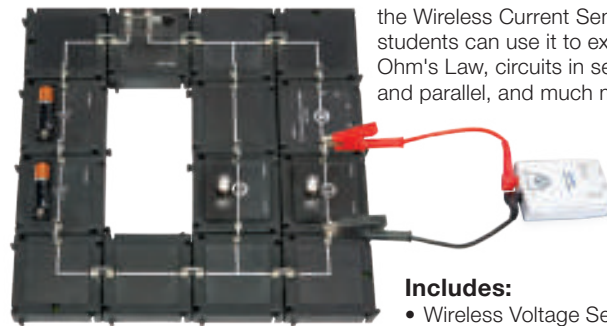
* Includes 8 sensors in a Gratnells® storage tray with custom insert.

Wireless Voltage Sensor

PS-3211A



The Wireless Voltage Sensor is ideal for exploring the fundamental concepts of electricity, voltage, and basic circuits. Complete with built-in overload protection, this sensor measures voltages up to ± 15 V, and features high-speed sampling rates when connected via USB. When combined with the Wireless Current Sensor, students can use it to explore Ohm's Law, circuits in series and parallel, and much more.

**Includes:**

- Wireless Voltage Sensor
- USB Cable
- Red, Banana-to-alligator-clip
- Black, Banana-to-alligator-clip

Specifications:**Low Voltage:****Range:** ± 5 V**Resolution:** 2 mV**High Voltage:****Range:** ± 30 V**Resolution:** 7 mV**Accuracy:** $\pm 1.0\%$ **Input Resistance:** 1 M Ω **Maximum Sample Rate:****USB:** 100 kHz (monitoring)**Bluetooth:** 20 kHz (continuous)**Connectivity:** USB and Bluetooth 5.2**Logging:** Yes**Battery Type:**

Rechargeable LiPo

Order Information

Wireless Voltage Sensor PS-3211A

Also available:

Wireless Voltage Sensor Pack* PS-3335

* Includes 8 sensors in a Gratnells® storage tray with custom insert.

Wireless Current Sensor Module

EM-3534



Since the Current Sensor Module is in the same form factor as the other modules, it naturally fits in series with the circuit components.

Included in Essential Physics Modular Circuits Kit EM-3536 on pages 236-237.

Specifications:**High Current:****Range:** ± 1 A**Resolution:** 0.2mA**Low Current:****Range:** ± 0.1 A**Resolution:** 0.02mA**Resistance:** 0.1 Ω **Maximum sample rate:** 100 kHz**Connectivity:** USB and Bluetooth 5.2**Logging:** No**Battery Type:** Rechargeable LiPo**Order Information**

Wireless Current Sensor Module EM-3534

Required:

Modular Circuits pp. 236-237

Wireless Voltage-Current Sensor

PS-4254

NEW

The Wireless Voltage-Current Sensor is a smart alternative to a traditional multimeter. It can be used as a standalone unit by using the built-in display, or connected to a computing device to output measurements to PASCO software for graphical analysis.

Connecting test leads is easy with separate ports provided for voltage and current. The ports are strategically arranged to remind students to connect the current sensor in series and the voltage sensor in parallel. Having separate ports makes it possible to measure voltage and current simultaneously with both measurements synchronized, even at high sample rates. The voltage and current measurements are also used to automatically calculate and display power and energy.

When used as a standalone unit, the sensor automatically detects if a signal is DC or AC. RMS values are displayed when an AC signal is detected (RMS assumes a pure sine wave). There is also no need for students to fiddle with range knobs since the sensor displays its full range. Students can also log data on the device to take measurements over time and view the logged data with PASCO software later.



Specifications:

Voltage:

Range: ± 5 V and ± 30 V

Resolution: 1 mV (@ ± 5 V range)

Resolution: 7 mV (@ ± 30 V range)

Input Resistance: 1 M Ω

Current:

Range: ± 0.1 A and ± 1 A

Resolution: 0.01 mA (@ ± 0.1 A range)

Resolution: 0.1 mA (@ ± 1 A range)

Input Resistance: 0.1 M Ω

Maximum Sample Rate:

USB: 50 kHz (monitoring)

Bluetooth: 10 kHz (continuous)

Connectivity: USB and Bluetooth 5.2

Logging: Yes

Battery Type: Rechargeable LiPo

Features:

- ▶ Measures voltage and current simultaneously with synchronized measurements
- ▶ Automatically calculates power and energy
- ▶ Built-in OLED display for viewing two live DC and AC measurements
- ▶ Ports arranged to emphasize connecting the current sensor in series and the voltage sensor in parallel
- ▶ Alarm warns students if the current measurement is too high to protect the sensor from damage
- ▶ Remote logging with built-in memory
- ▶ High speed sampling
- ▶ Rechargeable battery that can be easily replaced



Includes:

- Red, Banana-to-alligator-clip (2)
- Black, Banana-to-alligator-clip (2)
- USB-C cable

Order Information

Wireless Voltage-Current Sensor with Display

PS-4254

Physics Sensors

Wireless Charge Sensor

PS-3240



The Wireless Charge Sensor is designed to allow students to measure the electrostatic charge on an object. With the aid of PASCO data collection software, the sensor can measure either charge or voltage and plot them on a variety of displays.

The sensor comes with a BNC-to-alligator clip cable, which can be used to connect the sensor's BNC port to electrostatic equipment such as the Faraday Ice Pail. When used with the Faraday Ice Pail, the Wireless Charge Sensor can measure the total charge on an object by the induction method. The sensor can also be used as a high impedance voltmeter.

The sensor also comes with an E-Field Detector probe that plugs into the BNC port. The E-Field Detector is used to compare the relative charges of objects held near the sensor such as a balloon or a charged strip of cellophane tape.

Applications:

- ▶ Measure charge by induction
- ▶ Quantify the charge on a capacitor plate
- ▶ Discover the charge distribution on a conducting sphere

Features:

- ▶ No guessing if a charge is positive or negative – the polarity is shown.
- ▶ Measures both charge and voltage.



Specifications:

Charge: Range: $\pm 0.1 \mu\text{C}$ **Charge:** Resolution: 5 pC**Voltage:** Range: $\pm 10 \text{ V}$ **Voltage:** Resolution: 500 μV **Maximum Sample Rate:** 100 Hz**Connectivity:** USB and Bluetooth 5.2**Logging:** Yes**Battery Type:** Rechargeable LiPo

Includes:

- BNC-to-alligator clip cable
- E-Field Detector probe
- USB-C cable



Order Information

Wireless Charge SensorPS-3240

Wireless Sound Sensor

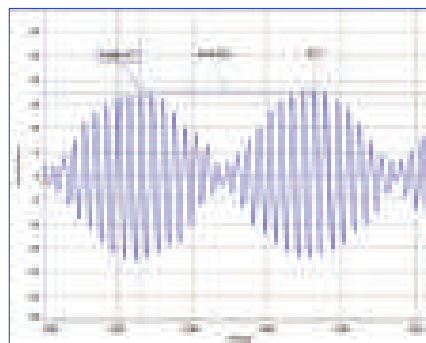
PS-3227



The PS-3227 Wireless Sound Sensor is two sensors in one wireless package: a sound wave sensor capable of measuring changes in relative pressure level as a function of time and a sound level sensor with both dBA and dBC weighted scales.

Sound Wave Sensor: The Sound Wave Sensor measures relative changes in sound pressure level as sound waves are incident on the sensor. With graphs of sound wave measurements versus time, students can explore and analyze wave properties like wave shape, wave speed, amplitude, frequency, wavelength, and much more. Students can use this sensor to explore superposition of waves and beat frequencies, while also exploring standing wave harmonics, and the presence of overtones. Sound wave measurements work beautifully with the scope and FFT displays in both SPARKvue and Capstone, and the Wireless Sound Sensor is capable of measuring sound wave data wirelessly at sample rates up to 100 kHz.

Sound Level Sensor: The Sound Level Sensor gives you true sound level (intensity) measurements with both dBA and dBC scales. The dBC weighting scale measures the intensity of sounds in a wide range of frequencies within, and outside the frequency range of human hearing. The dBA weighting scale filters some of the sound frequencies from a sound source to more closely match the frequency response of the human ear. The dBA scale is commonly used in the workplace to determine the sound level an employee will experience in typical working conditions. Sound level and noise pollution are key measurements in environmental science.



This new sensor gives you a wireless solution to measure sound level with all the capability of a sound level meter, but adds the flexibility of recording data continuously as a function of time.

Easily observe and measure beat frequencies

Specifications:

Sound Wave Sensor:

Range: 100 to 20,000 Hz**Maximum Sample Rate:** 100 kHz

Sound Level Sensor:

Range: 50 to 110 dB**Resolution:** 0.1 dB**Accuracy:** $\pm 2 \text{ dB}$ **Response:** A or C weighted**Maximum Sample Rate:** 20 Hz**Connectivity:** USB and Bluetooth 5.2**Logging:** Yes**Battery Type:** Rechargeable LiPo

Includes:

- USB charging cable
- Threaded handle for mounting the sensor to a rod stand

Order Information

Wireless Sound SensorPS-3227

Also available:

Wireless Sound Sensor Pack*PS-3342

* Includes 8 sensors in a Grattells® storage tray with custom insert.

Wireless Light and Color Sensor

PS-3248

- Four sensors in one
- Ambient lux
- Photosynthetically active radiation
- Irradiance
- Detect RGB colors separately
- Bluetooth 5.2 wireless



The Wireless Light and Color Sensor features two separate apertures: One measures ambient light from the side of the box, and the other measures percent color of directional light at the end of the box.

Applications:

- Studying solar energy
- Reflection, absorption, and transmission of light through clear, opaque, and variously colored translucent mediums.
- Investigating polarization and reflectivity
- Modeling planetary motion
- Verifying the inverse square law
- Investigating insolation (solar radiation) and seasons
- Indirect PAR measurements for biological studies



PASCO's Wireless Light Sensor provides students with the tools to explore the electromagnetic spectrum, model planetary motion, and relate photosynthesis to light color and intensity.



*Spot Sensor for color comparative analysis.
Ambient for light properties and UV index*



Recent eclipse light variation

Specifications:

- Spectral Response:** 340 nm to 1150 nm
- Illuminance Range:** 0 to 131,000 lux
- Irradiance Range:** 0 to 1362 W/m²
- PAR Range:** 1 to 2400 μmol/m²/s
- UV Index Range:** 0 to 12 (typical in daylight)
- RGB Range:** 0 to 100% of combined colored light
- Maximum Sample Rate:** 2 Hz (ambient); 20 Hz (spot)
- Connectivity:** USB and Bluetooth 5.2
- Logging:** Yes
- Battery Type:** Coin Cell

Order Information

Wireless Light and Color Sensor.....PS-3248

Also available:

Wireless Light Sensor Pack*PS-3338

* Includes 8 sensors in a Grattells® storage tray with custom insert.

Physics Sensors

Wireless Magnetic Field Sensor

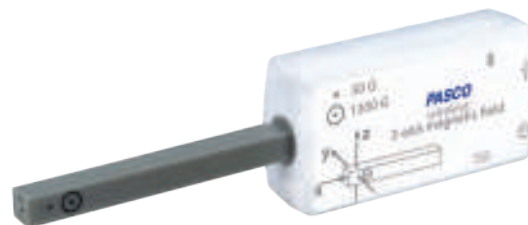
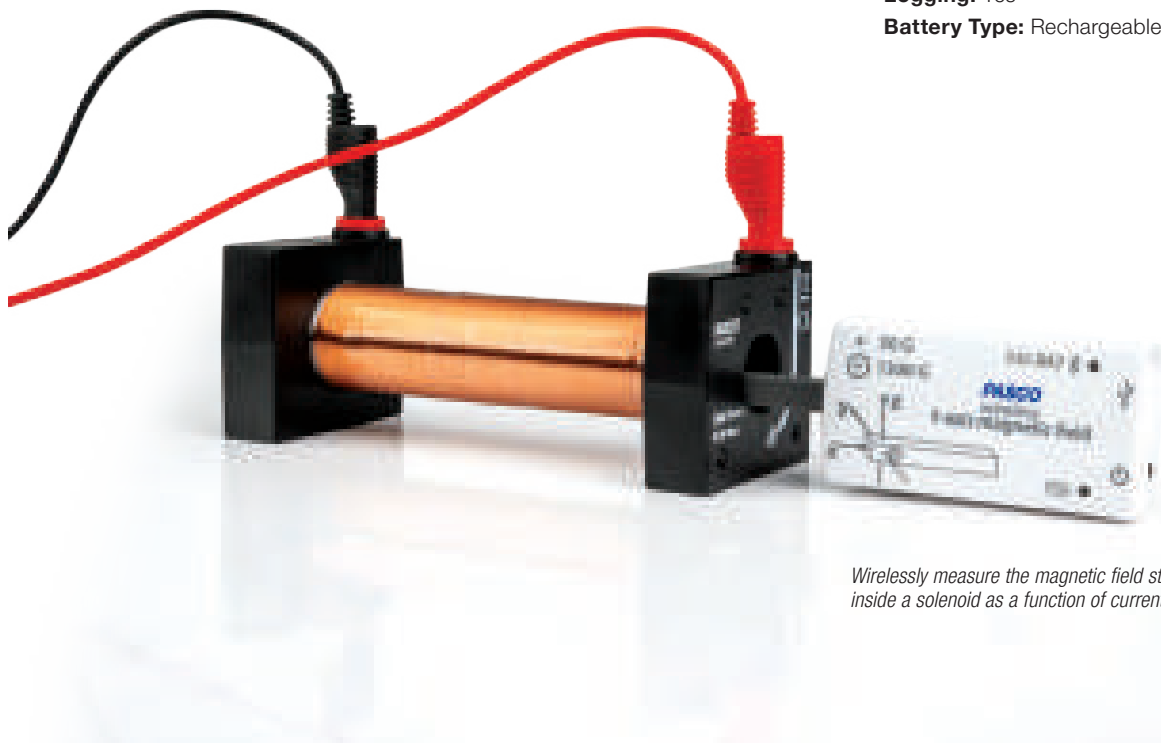
PS-3221

- ▶ Simultaneous measurements on three axes
- ▶ Dual range: ± 50 G and ± 1300 G
- ▶ Sensitive enough to measure the Earth's magnetic field
- ▶ Measure fields from permanent magnets and current-carrying coils

This 3-Axis Magnetic Field Sensor can sense the Earth's magnetic field, magnetic fields from current-carrying coils, and permanent magnets. There are two ranges: ± 50 gauss and ± 1300 gauss. This sensor is primarily for static fields.

Applications:

- ▶ Measure magnetic field of permanent magnets
- ▶ Measure Earth's magnetic field
- ▶ Measure field strength of Helmholtz coils

**Specifications:****High Magnetic Field:****Range:** ± 1300 G**Resolution:** 1 G**Low Magnetic Field:****Range:** ± 50 G**Resolution:** 0.01 G**Maximum Sample Rate:** 100 Hz**Connectivity:** USB and Bluetooth 5.2**Logging:** Yes**Battery Type:** Rechargeable LiPo

Wirelessly measure the magnetic field strength inside a solenoid as a function of current.

Includes:

- 3-Axis Magnetic Field Sensor
- Sensor Mounting Rod
- USB Charging Cable

Order Information

Wireless Magnetic Field Sensor PS-3221

Recommended:

Zero Gauss Chamber EM-8652

p. 46

Wireless Geiger Counter

PS-3238

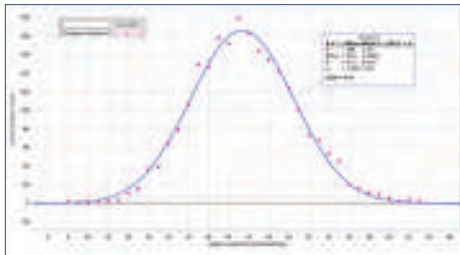


The PASCO Wireless Geiger Counter counts beta, gamma and alpha radiation particles as they enter the Geiger-Müller detector tube inside the counter. Designed for easy mounting, the Geiger Counter provides superior position control in inverse square law labs, as well as an audible beep to indicate the detection of ionizing radiation. The front plastic snout fits conveniently inside the NU-3344 Sample Holder stand (available separately).

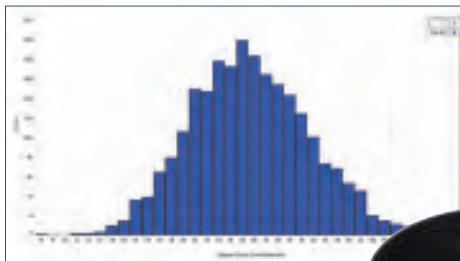
With the Wireless Geiger Counter, students can wirelessly control the high voltage supplied to the Geiger-Müller tube inside the counter, enabling them to make measurements of counts/interval for different tube voltages. They can also plot counts/interval versus tube voltages to experimentally observe the Geiger plateau characteristics of the tube.

Features:

- Built-in metal mesh screen to protect the delicate mica window in the front of the Geiger-Müller detector tube
- Audible beep to indicate count can be easily switched on or off
- **Versatile positioning options:** either in the NU-3344 Sample Holder, hand-held, or mounted on a rod stand
- Convenient design natively fits the PASCO NU-3344 Sample Holder
- Provides wireless control over the high voltage supplied to the Geiger-Müller tube inside the counter for Geiger plateau experiments



Demonstrates the statistical (gaussian or poisson) nature of counts/interval measured from a radioactive source with a long half-life.



Includes:

- Wireless Geiger Counter
- USB Cable
- Threaded handle for mounting the sensor to a rod stand

Order Information

Wireless Geiger Counter.....PS-3238

Applications:

- Observe the inverse square law
- Measure the Geiger plateau associated with a Geiger-Müller tube
- Demonstrate the shielding properties of different materials and different types of ionizing radiation

Specifications:

Sensitivity: Alpha, Beta, Gamma

Count Detection:

Switchable audio signal

Gas Filling: Ne +Halogen

Effective Tube

Diameter: 9.1 mm

Window Thickness:

1.5 to 2.0 mg/cm²

High Voltage Control Range:

150 to 650 VDC

Standard Operating Voltage:

500 VDC

Connectivity: USB and

Bluetooth 5.2

Logging: Yes

Battery Type: Rechargeable

LiPo



The NU-3344 Sample Holder stand is not included with the PS-3238 Wireless Geiger Counter, but is available separately. See below.

Geiger Counter Sample Holder

NU-3344

The PASCO Geiger Counter Sample Holder makes it easy to mount and position the PS-3238 Wireless Geiger Counter for inverse square law labs, radiation shielding labs, and other radiation labs. The front plastic snout on the Wireless Geiger Counter is designed to fit conveniently inside the Sample Holder stand, which stabilizes the front of the counter's detector tube exactly 1 cm from the first slot in the holder.

The stand includes a radioactive sample holder tray and 5 pieces of 7 cm x 7 cm aluminum shielding material. The stand has eight slots designed to hold the included radioactive sample holder tray or shielding material. Each slot in the holder is spaced 1 cm apart to make changing the spacing between the Geiger Counter, radioactive sample, or shielding materials quick and easy.

Features:

- Includes one Radioactive Sample Holder and five pieces of Aluminum Shielding (0.4 mm thick)
- Eight slots for holding radioactive samples or shielding materials, spaced 1 cm apart

Includes:

- Stand with 8 Sample Slots
- Radioactive Sample Tray
- Aluminum Shielding Material (0.4 mm thick) (5)



Order Information

Geiger Counter Sample Holder NU-3344

Chemistry Sensors

UV-Vis Spectrometer

SE-3607

- Uses PASCO's award-winning Spectrometry software
- Spectral scans from 180 to 1050 nm
- Easy to calibrate



The SE-3607 is an easy-to-use, wide range UV-Vis spectrometer that delivers fast, accurate and reliable performance for routine analyses in chemistry and biochemistry teaching labs.

With USB connectivity and cross-platform Spectrometry Software, the PASCO UV-Vis Spectrometer improves collaboration between lab members, enabling data collected on a computer or laptop to be analyzed on tablets, iPads, and Chromebooks*.

* Chromebooks are not compatible with the PASCO UV-Vis Spectrometer for data collection (analysis only).

Specifications:

Dimensions: 19.5 ? 24.5 ? 7.0 cm

Light Source: Deuterium (UV) Tungsten (Vis)

Detector: 2048 CMOS linear (0.3nm reporting interval)

Wavelength Range: 180 to 1050 nm

Wavelength Accuracy: 1.0 nm

Grating: 500 lines/mm

Signal to Noise: 2000:1

Optical Resolution: 1.5 nm

Photometric Accuracy: $\pm 5\%$

Photometric Range (Best Accuracy): 0.1 to 1.0

(reports full range 0.0 to 3.0)

Typical Scan Time (Depends on Integration): 4 ms to 10 s

Connectivity: USB only

Power Consumption: 2.5 A startup 350 mA continuous

Power Supply: 100 - 240 VAC to 24VDC @ 2.5A

Warranty: 5 year limited on hardware, 1 year on lamps

**Applications:**

- Determination of solution concentrations
- Identification of unknown substances
- Measurement of reaction rates or rate of decay
- Colorimetric assays (e.g., BCA, Bradford, Lowry)
- Purity testing of synthesized compounds
- Determination of the equilibrium constant
- Determination of molar absorption coefficients
- Quality testing (e.g., fermentation mediums, food adulteration, QA levels)

Includes:

- Semi-Micro Volume Cuvettes (Qty. 10)
- Cuvette Rack (EC-3590)
- USB-A to USB-B Cable
- External AC Adapter, 24 V Power Supply
- Foam Lined Carrying Case (ABS)
- Spectrometry Software

**Order Information**

UV-Vis Spectrometer.....	SE-3607
Recommended:	
UV Quartz Cuvettes (Qty. 2)	SE-3611
UV-Vis Fiber Optic Kit.....	SE-7182
Replacement Parts:	
Deuterium Replacement Bulb.....	SE-3608
Tungsten Replacement Bulb.....	SE-3609

Disposable UV Semi-Micro Volume Cuvettes (qty. 10)

SE-3610

Includes:

- Disposable UV Semi-Micro Volume Cuvettes (10)
- Cuvette Rack (EC-3590) (2)

**Order Information**

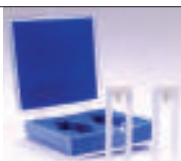
Disposable UV Semi-Micro Volume Cuvettes (qty. 10).....	SE-3610
---	---------

UV Quartz Cuvettes (qty. 2)

SE-3611

Includes:

- UV Quartz Cuvette (2)
- Teflon Cuvette Cap (2)

**Order Information**

UV Quartz Cuvettes (qty. 2).....	SE-3611
----------------------------------	---------

UV-Vis Fiber Optic Kit

SE-7182

Enhance the capabilities of your PASCO UV-Vis Spectrometer (SE-3607) for the analysis of emission sources, external samples, and the classification of lasers with the UV-Vis Fiber Optic Kit. This complete kit includes a quartz core cable (50-cm quartz core, 0.2-mm diameter) and a front surface mirror, reflective cuvette. Other applications include: analysis of external absorption spectra, measurement of electronic transition energies, calculation of the Rydberg constant, and determination of light source energies.

**Includes:**

- Quartz core cable with attached reflective cuvette

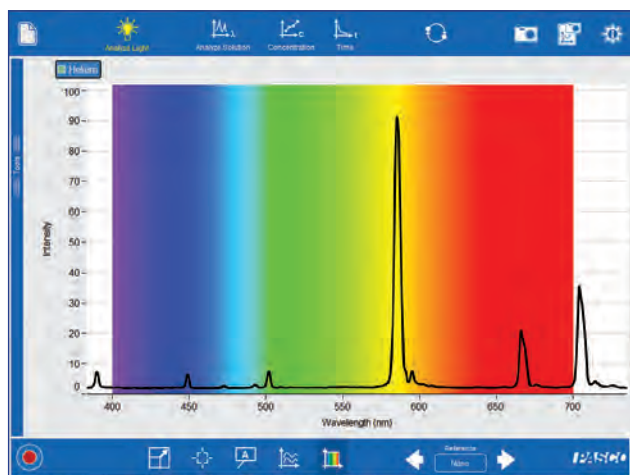
Order Information

UV-Vis Fiber Optic Kit.....	SE-7182
-----------------------------	---------

Wireless Spectrometer (Vis)

PS-2600A

The award-winning PASCO Wireless Spectrometer is specifically designed for modern chemistry, biology, and physics labs. It connects to student devices via USB or Bluetooth Low Energy and includes free Spectrometry software with built-in tools for spectral analysis. Scan times are fast, enabling students to collect a full spectrum of data in less than a second. Three plots are provided for common applications, including Wavelength vs. Absorbance (or emission), Concentration vs. Absorbance (Beer's law), or Absorbance vs. Time (kinetics).



Visualize absorbance across the full visible spectrum and identify peaks with a large digits display.



Includes:

- Cuvettes (10)
- Spectrometry Software



Applications:

- ▶ Photosynthesis with DPIP
- ▶ Absorption spectra of plant pigments
- ▶ Rate of an enzyme-catalyzed reaction
- ▶ Absorption spectrum of chlorophyll
- ▶ Emission spectra of light from flame tests or other sources
- ▶ Easily identify peak wavelengths for concentration data
- ▶ Study the relationship between concentration and absorbance (Beer's Law)
- ▶ Reaction Kinetics
- ▶ Fluorescence of chlorophyll and other compounds
- ▶ Photosynthesis with algae beads using a pH indicator

Specifications:

Resolution: 2 to 3 nm FWHM

Cuvette Material: Polystyrene

Detection Range: 390 to 950 nm

Photometric Range (Best Accuracy): 0.1 to 1.0
(Reports full range from 0.0 to 3.0)

Spectrometer Body Material: ABS plastic

Fluorescence Excitation Wavelengths: 405 nm and 500 nm

Industry Standard Cuvette Size: 12 x 12 x 45 mm,
10 mm inner path

Light Source: LED-boosted tungsten

Operation & Light control: Software-based
(using PASCO Spectrometry Software)

Connectivity: USB and Bluetooth 5.2

Charging/ Data Port Type: Mini USB

Order Information

Wireless Spectrometer (Vis)PS-2600A

Recommended:

Fiber Optics Cable.....PS-2601

p. 310

//code.Node

PS-3231

The //code.Node is a turnkey coding solution that combines real-world sensor inquiry, Blockly coding, and live data displays to drive computational thinking in STEM learning. It includes six interactive sensors and four device outputs that measure and respond to phenomena using code created in SPARKvue or Capstone software.

**Sensor Inputs:**

- ▶ Temperature
- ▶ Motion
- ▶ Sound
- ▶ Light
- ▶ Magnetic Field

Device Outputs:

- ▶ Speaker
- ▶ RGB LED
- ▶ 5x5 LED array
- ▶ Software displays

Applications:

- ▶ Introduce computational thinking into science lessons.
- ▶ Explore science concepts using coding and data collection.
- ▶ Create a program to identify changes in your environment.
- ▶ Program songs, games, countdowns, alarms, and much more!

**Specifications:****Maximum Sample Rate:** 100 Hz**Light Level Sensor Range:** 600 lx to 50,000 lx (not calibrated)**Sound Level Sensor Range:** 70 dB to 100 dB (not calibrated)**Magnetic Field Sensor Range:** ± 50 gauss**Acceleration Sensor Range:** ± 8 g**Speaker Frequency Range:** 10 Hz to 10,000 Hz**Ambient Temperature Sensor****Range:** -25°C to 40°C **Resolution:** 0.05°C **Accuracy:** $\pm 1^{\circ}\text{C}$ **Includes:**

- //code.Node
- USB Charging Cable

Order Information

//code.Node.....PS-3231

Also available:

//code.Node Multi-Pack (set of 8)*.....PS-3311

* Includes 8 //code.Nodes, 8 holders, and 8 USB charging cables in storage box.

//control.Node

PS-3232

See STEM section
for applications.
(pages 82-84)

**Includes:**

- //control.Node
- USB Charging Cable

The purpose of the //control.Node is to control devices such as stepper motors, servo motors, fans, and pumps. The //control.Node also provides battery power for these devices. The //control.Node wirelessly communicates via Bluetooth to a computer and it receives instructions written in Blockly code to control the devices. Code can be uploaded to the //control.Node and run autonomously without connection to a computer.

The //control.Node can also send sensor readings to the computer while executing code. These sensor readings can be used as feedback in the program and can also be displayed live in graphs and other displays in PASCO Capstone or SPARKvue. It has one sensor port for PASCObot Modules or the Greenhouse Sensor. It has a rechargeable battery and can be powered using the USB connection.

Built-in Features:

- ▶ Two Power Output Channels for Stepper Motors and Power Output Board
- ▶ Two Servo Ports for Regular Servos and Continuous Rotation Servos
- ▶ Accelerometer
- ▶ Speaker
- ▶ Sensor Port
- ▶ Rechargeable Lithium Ion Battery
- ▶ Bluetooth BLE Communication
- ▶ USB Port for Charging and Communication
- ▶ Two 6-32 Threaded Holes for Mounting

Specifications:**Power Output Ports:** ± 5 VDC, 0.7 A**Power Output Ports:** Auto-ID stepper motors and Power Output Module**Power Output Ports:** 8-pin modular jack**Servo Ports:** Accepts standard servos and continuous rotation servos**Servo Ports:** 3-pin connector**Servo Ports:** Not auto-ID**Servo Ports:** Built-in servo current sensor for detecting load**Sensor Port:** I2C**Sensor Port:** 6-pin modular jack**Acceleration Sensor:** ± 16 g, 3-axis**Speaker Frequency Range:** 10 Hz to 10,000 Hz**Dimensions:** 11.5 x 5 x 3 cm**Mass:** 142 g**Connectivity:** USB and Bluetooth 5.2**Logging:** No**Battery Type:** Rechargeable LiPo**Order Information**

//control.Node.....PS-3232

Wireless Sensor Charging Station

PS-3599

- Charge all types of PASCO Wireless Sensors
- Remove partitions to resize sensor bays

This versatile charging station can be configured to fit any size sensor by adding or removing partitions.



Includes:

- Wireless Sensor Charging Station
- USB Charging Cables (10) (13 cm x 35 cm)
- Power Adapter
- Removable Partitions (9)



Order Information

Wireless Sensor Charging Station PS-3599

Smart Cart Charging Garage

ME-1243

Charge up to five Smart Carts at once. Provides storage for the carts and accessory bumpers. Includes power adapter.



Order Information

Smart Cart Charging Garage ME-1243

Wireless Sensor Storage Trays

- Each tray can store up to 10 Wireless Sensors.



Explore solutions for sensor storage at pasco.com/storage

Wireless Sensor Packs

- Includes 8 sensors in each Grattells® storage tray



Wireless Colorimeter & Turbidity Sensor Pack (PS-3334)



Wireless Temperature Sensor Pack (PS-3330)

Also available:

- Wireless pH Sensor Pack (PS-3331)
- Wireless Conductivity Sensor Pack (PS-3332)
- Wireless Pressure Sensor Pack (PS-3333)
- Wireless Voltage Sensor Pack (PS-3335)
- Wireless Current Sensor Pack (PS-3336)
- Wireless Motion Sensor Pack (PS-3337)
- Wireless Light Sensor Pack (PS-3338)
- Wireless Force Acceleration Sensor Pack (PS-3339)
- Wireless Weather Sensor with GPS Pack (PS-3340)
- Wireless CO₂ Sensor Pack (PS-3341)
- Wireless Sound Sensor Pack (PS-3342)

See all our
Wireless
Sensor
Packs at
pasco.com

Grattells® Rolling Carts

EP-3574 (2-column)

EP-3575 (3-column)

Assembly is required.



Grattells® Storage Trays with Lids



For size specifications and more information on Grattells Rolling Carts and Storage Trays, see page 213 or go to pasco.com

Comprehensive Physics Systems

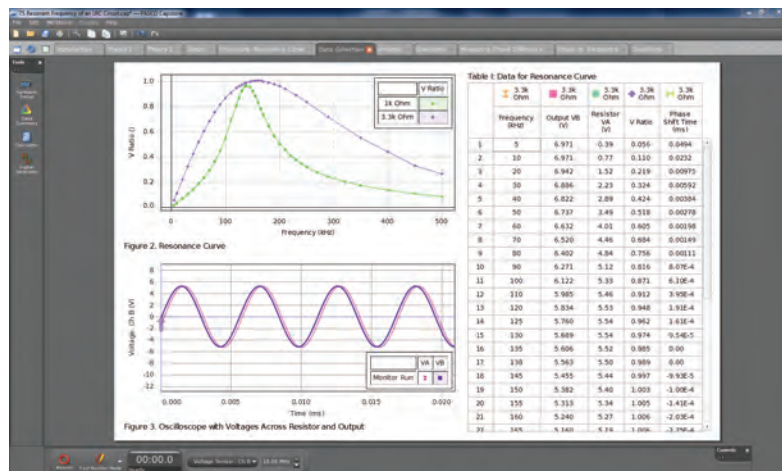
Comprehensive 850 Physics System

UI-5800E

► Designed for the 850 Universal Interface and PASCO Capstone™ Software

The 850 Comprehensive Physics System consists of 83 experiments and all the equipment and sensors needed to perform these experiments. The experiments cover topics, such as mechanics, waves, optics, thermodynamics, and electromagnetism. The included experiment manual contains instructions written in Word®, a PASCO Capstone electronic workbook, and sample data.

The key to a successful lab is a PASCO Capstone electronic workbook. These workbooks have step-by-step instructions with live, embedded displays, such as graphs, FFTs, oscilloscopes, and meters. They contain the theory, experiment set-up, procedure, data analysis, and questions designed to get students to think about their results. These electronic workbooks can be easily modified by teachers to fit their individual needs.



See page 72 for a list of experiments in the included manual. Download free experiments at pasco.com/850experiments

Comprehensive 850 System (UI-5800D)

Includes:

- UI-5801C Mechanics Bundle
- UI-5802A Waves, Optics and Thermodynamics Bundle
- UI-5803 Electromagnetism Bundle
- UI-5813 Experiment Manual

Order Information

Comprehensive 850 Physics System.....UI-5800E

Required:

850 Universal InterfaceUI-5000 p. 20
PASCO Capstone™ Software.....pp. 8-11

Comprehensive 850 Mechanics Bundle

UI-5801C

(Component of the 850 Comprehensive System UI-5800D)

Includes:

- Force Sensor Track Bracket ME-6622
- Cart Adapter Accessory ME-6743
- Compact Cart Mass (2) ME-6755
- Time-of-Flight Accessory ME-6810A
- Photogate Mounting Bracket ME-6821A
- Mini Launcher ME-6825B
- Dynamics Cart Magnetic Damping ME-6828
- Mini Ballistic Pendulum Accessory ME-6829
- Spring Cart Launcher ME-6843
- PAScar (red) ME-6933
- PAScar (blue) ME-6934
- Super Fan Cart ME-6977
- Density Set ME-8569A
- Discover Friction Accessory ME-8574
- Large Rod Base ME-8735
- 45 cm Stainless Steel Rod ME-8736
- 90 cm Stainless Steel Rod ME-8738
- Picket Fences (Smart Timer) (2) ME-8933
- Dynamics Track End Stop (2) ME-8971
- Dynamics Track Feet (Pair) ME-8972
- Mass and Hanger Set ME-8979
- Elastic Bumper ME-8998
- IDS Spring Kit (12) ME-8999
- Picket Fence ME-9377A



- Large Table Clamp ME-9472
- 1.2 m Aluminum Dynamics Track ME-9493
- Photogate Head (2) ME-9498A
- Pendulum Clamp ME-9506
- Multi-Clamp (2) ME-9507
- Variable Speed Motorized Cart ME-9781
- Centripetal Force Pendulum ME-9821
- PASPORT Motion Sensor (2) PS-2103A
- PASPORT Rotary Motion Sensor PS-2120A
- PASPORT High Resolution Force Sensor (2) PS-2189
- Wireless Acceleration/Altimeter PS-3223
- Pulley Mounting Rod SA-9242
- No-Bounce Pad SE-7347
- Braided Physics String SE-8050
- Comprehensive 850 Physics System Experiment Manual UI-5813
- Rotational Inertia Accessory ME-3420

Order Information

Comprehensive 850 Mechanics Bundle ... UI-5801C

Comprehensive 850 Waves, Optics and Thermodynamics Bundle

UI-5802B (Component of the 850 Comprehensive System UI-5800D)



Includes:

• Sound Sensor with Microphone	UI-5101
• Energy Transfer - Calorimeter	ET-8499
• Precision Diffraction Slits	OS-8453
• Green Diode Laser	OS-8458B
• Color Mixer Accessory Kit	OS-8495
• Color Mixer	OS-8496
• Basic Optics System	OS-8515D
• Red Diode Laser	OS-8525A
• Polarization Analyzer	OS-8533A
• Linear Translator	OS-8535A
• Adjustable Focal Length Lens	OS-8494
• PASPORT Absolute Pressure Sensor	PS-2107
• PASPORT Quad Temperature Sensor	PS-2143
• PASPORT High Sensitivity Light Sensor	PS-2176
• Sympathetic Resonance Box Set	SE-7345
• Banana Plug Cord - Red (5 pack)	SE-9750
• Radiation Cans	TD-8570A
• Absolute Zero Sphere	TD-8595
• Ideal Gas Law Apparatus	TD-8596A
• Resonance Air Column	WA-9606
• String Vibrator	WA-9857A
• Mini Speaker	WA-9605

The experiments for this section require components of the 850 Comprehensive Mechanics UI-5801C.

See page 72 for manual. Download free experiments at pasco.com/850experiments

Comprehensive 850 Electromagnetism Bundle

UI-5803 (Component of the 850 Comprehensive System UI-5800E)



Includes:

• Alnico Bar Magnets (2)	EM-8620
• Zero Gauss Chamber	EM-8652
• AC/DC Electronics Laboratory	EM-8656
• Basic Electrostatics System	ES-9080B
• Field Mapper Kit	PK-9023
• PASPORT Current Probe (2)	PS-2184
• PASPORT 2-Axis Magnetic Field Sensor	PS-2162
• Banana Plug Cord Sets, 30 cm Length	SE-7123
• Plotting Compass Set (20)	SE-8680
• Dip Needle	SE-8619
• Voltage Sensor (unshrouded) (4)	UI-5100
• BNC Function Generator Output Cable (unshrouded)	UI-5119
• Resistor Capacitor Inductor Network	UI-5210

The experiments for this section require components of the 850 Comprehensive Mechanics UI-5801B.

See page 72 for a list of experiments in the included manual.

Order Information

Comprehensive 850 Physics System.....	UI-5800E
Required:	
850 Universal Interface	UI-5000 p. 20
PASCO Capstone Software	pp. 8-11
Also available separately:	
Comprehensive 850 Mechanics Bundle	UI-5801C
Comprehensive 850 Waves, Optics and Thermodynamics Bundle	UI-5802B
Comprehensive 850 Electromagnetism Bundle	UI-5803
Comprehensive 850 Physics System Experiment Manual	UI-5813

Comprehensive 850 Physics System (UI-5800D)

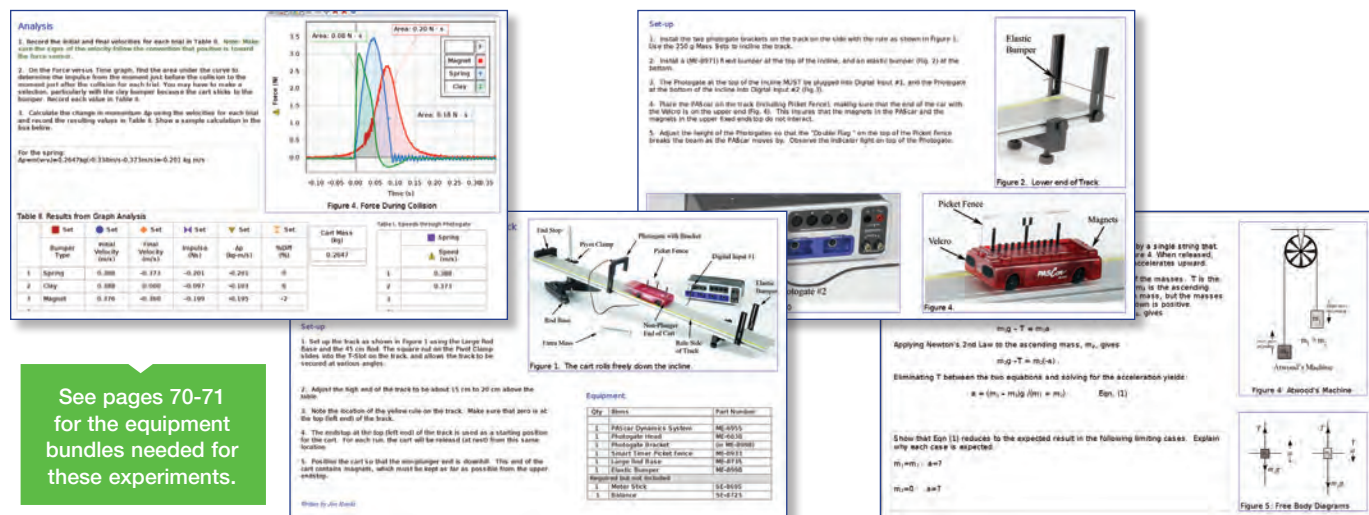
Includes:

- Comprehensive Mechanics (UI-5801C)
- Comprehensive Waves, Optics, and Thermodynamics (UI-5802A)
- Comprehensive Electromagnetism (UI-5803)

Comprehensive 850 Physics System Experiment Manual

UI-5813

Designed for advanced high school and college-level physics, the Comprehensive 850 Physics System Experiment Manual includes dozens of digital experiments with preformatted Capstone workbook files. Each Capstone workbook file includes detailed step-by-step instructions, sample data, interactive displays, and intuitive analysis tools that help students conceptualize topics through data collection, visualization, and analysis.



Comprehensive 850 Physics System Experiment List

Mechanics

(49 Experiments)

- Introduction to Measurement
- Uncertainty and Error Analysis
- Relative Motion in One Dimension
- Match Graph: Position and Velocity vs. Time
- Instantaneous and Average Speed
- Position and Velocity
- Velocity and Acceleration
- Equations of Motion
- Acceleration of a Freely Falling Ball
- Acceleration of a Freely Falling Picket Fence
- Acceleration on an Incline
- Projectile Motion
- Projectile Motion – Against a Wall
- Newton's First Law – No Net Force
- Newton's Second Law
- Force and Acceleration
- Inertia and Newton's Second Law
- Newton's Third Law
- External Forces and Newton's Third Law
- Atwood's Machine
- Acceleration Up an Inclined Plane
- Static Equilibrium
- Coefficients of Static and Sliding Friction
- Friction and Newton's Laws
- Magnetic Drag
- Terminal Velocity for Objects of Different Surface Areas and Masses
- Centripetal Force on a Pendulum
- Conservation of Energy on an Inclined Plane
- Gravitational Potential Energy
- Hooke's Law and Elastic Potential Energy
- Conservation of Energy for a Simple Pendulum
- Work-Energy Theorem
- Conservation of Momentum in Collisions
- Impulse and Change in Momentum
- Ballistic Pendulum
- Newton's Second Law for Rotation
- Rotational Inertia

Waves, Optics, and Thermodynamics

(22 Experiments)

- Rotational Kinetic Energy
- Conservation of Angular Momentum
- Simple Harmonic Motion – Mass on a Spring
- Oscillations of Cart and Springs
- Oscillation Equations of Motion
- Driven Harmonic Motion – Mass on a Spring
- Physical Pendulum
- Period of a Large Amplitude Pendulum
- Variable-g Pendulum
- Physical Pendulum Minimum Period
- Archimedes' Principle – Buoyant Force

Electromagnetism

(16 Experiments)

- Electrostatic Charges
- Electric Field Mapping
- Ohm's Law
- Series/Parallel Circuits
- Kirchhoff's Laws:
Resistors in Series and Parallel
- Capacitance
- RC Circuit
- Resonant Frequency of an LRC Circuit
- General Properties of Diodes
- Build a Rectifier
- Transistor 1 –
The NPN Transistor as a Digital Switch
- Transistor 2 – Measure the Current Gain
- Earth's Magnetic Field
- Magnetic Field Mapping
- Induction – Magnet Through a Coil
- Magnetic Field in a Current-Carrying Coil

This manual is included in both the 850 Comprehensive Physics System UI-5800 and the 850 Comprehensive Mechanics System UI-5801.

Download free experiments at
pasco.com/850experiments

Order Information

Comprehensive 850 Physics System
Experiment Manual UI-5813
Word® files, PASCO Capstone files, and graphics
are supplied on a flash drive.

Mechanics 850 System (Includes 850 Universal Interface)

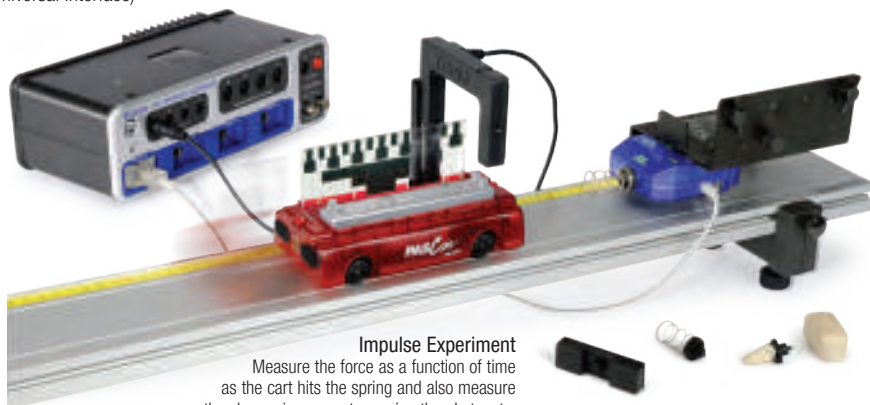
UI-5820

- Integrates probeware and physics equipment
- Includes 850 Universal Interface
- Perform a wide variety of mechanics experiments

When used together, PASCO's probeware and physics apparatus can help students learn the core concepts of mechanics more effectively. The Mechanics 850 System includes all the equipment students need to perform a wide variety of mechanics experiments.

The new manual features ten hands-on experiments that make full use of the system's components. This makes it an ideal solution for performing the key labs that are standard in all mechanics courses.

PASCO Capstone software (not included) enriches the labs with its interactive displays and analysis tools.



Impulse Experiment

Measure the force as a function of time as the cart hits the spring and also measure the change in momentum using the photogate.

Ten Experiments Included in Manual (UI-5821)

Title	Purpose	Sensors Used
Acceleration Down an Incline	Discover how the acceleration of an object down an incline depends on the angle of incline. Measure the acceleration due to gravity.	Photogate with picket fence
Newton's Second Law	Verify Newton's Second Law by varying the applied force and the mass.	Motion Sensor
Kinetic Friction I	Measure the kinetic coefficient of friction.	Motion Sensor
Kinetic Friction II	Study how the coefficient of kinetic friction depends on the velocity, acceleration, surface area, and weight of the object.	Photogate with pulley
Impulse and Momentum	Measure the impact force of a cart and compare the impulse to its change in momentum.	Force Sensor/ photogate
Conservation of Momentum in Explosions	Verify that momentum is conserved for two carts pushing off from each other.	Two photogates with picket fences
Conservation of Momentum in Inelastic Collisions	Verify that momentum is conserved in inelastic collisions and that kinetic energy is not conserved.	Two photogates with picket fences
Conservation of Momentum in Elastic Collisions	Verify that momentum is conserved in elastic collisions.	Two photogates with picket fences
Conservation of Energy	Show spring potential change into kinetic energy.	Motion Sensor/ photogate with picket fence
Simple Harmonic Motion	Measure the period of oscillation of a spring and mass system and compare it to the theoretical value. Evaluate the effect of changing the mass and spring constants.	Photogate and flag



Includes:

- 850 Universal Interface UI-5000
- PASPORT High Resolution Force Sensor PS-2189
- PASPORT Motion Sensor PS-2103A
- Photogates and Fences Dynamics System ME-9471A
- Aluminum Dynamics Track, 1.2 m ME-9493
- Discover Friction Accessory ME-8574
- Force Sensor Track Bracket ME-6622
- Mass and Hanger Set ME-8979
- Super Pulley with Clamp ME-9448B
- Plunger Cart ME-9430
- Collision Cart ME-9454
- Spring Cart Launcher ME-6843
- Smart Fan Accessory ME-1242
- Mechanics 850 System Lab Manual UI-5821

Order Information

Mechanics 850 System.....UI-5820

Required:

PASCO Capstone Software.....pp. 8-11

550 Physics

Universal 550 Physics Experiment Bundle

UI-5830B

The Universal 550 Physics System provides a complete set of labs for mechanics, heat, light, sound, and electromagnetism. Each lab consists of student instructions in a Word® document that the instructor can modify as they like, a PASCO Capstone setup file ready for data collection, a Capstone file with sample data, and all the lab equipment required for the experiment.

This system was designed to use both wireless and wired sensors, combined with the 550 Universal Interface that serves as a DC power supply and function generator.

NOTE: The 550 Universal Interface (UI-5001) is not included.



Mechanics

Mechanics Includes:

- Rotational Inertia Accessory
- Red and Blue Smart Carts
- 1.2 m Aluminum Dynamics Track
- Friction Block
- Smart Fan Accessory
- Wireless Accelerometer/Altimeter
- Smart Cart Rod Stand Adapter
- Cart Mass (Set of 2)
- Pi Set
- Photogate Mounting Bracket
- Mini Launcher
- Mini Ballistic Pendulum Accessory
- Density Set
- Large Rod Base
- 45 and 90 cm Stainless Steel Rods
- Mass and Hanger Set
- Elastic Bumper
- Spring Kit
- Picket Fence
- Multi Clamps (2)
- Large Table Clamp
- Photogate Head (2)
- Pendulum Clamp
- PASPORT Rotary Motion Sensor
- No-Bounce Pad
- Braided Physics String
- Pulley Mounting Rod
- Bumper Accessory Set
- Super Pulley with Clamp
- Experiment Manual



Heat, Waves, Sound, and Light

Heat, Waves, Sound, and Light Includes:

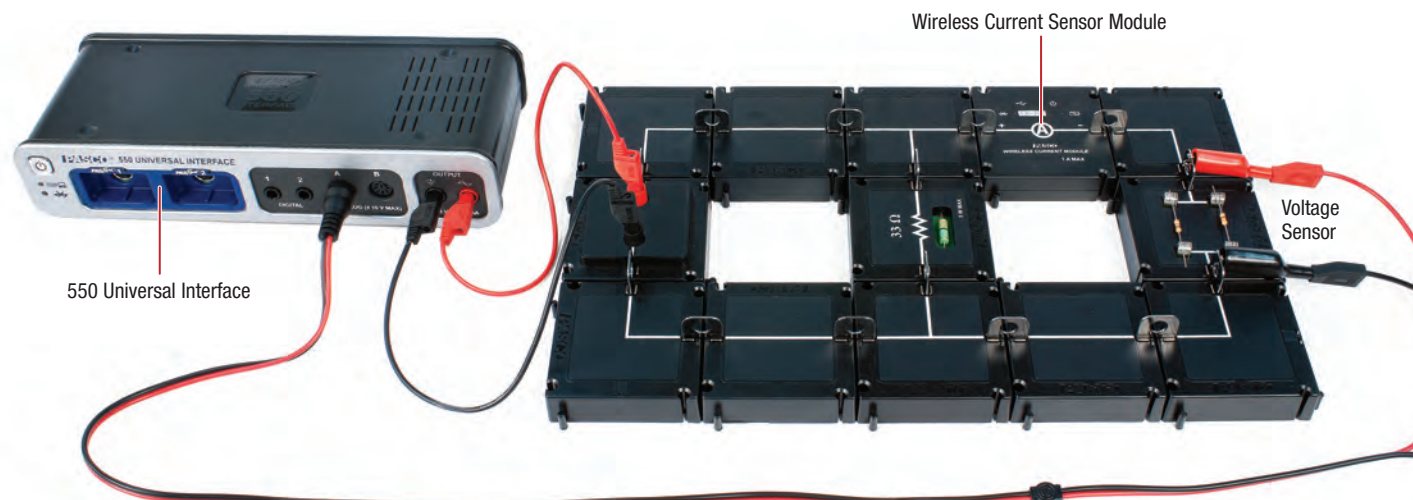
- Sound Sensor
- Calorimeter Cup with Lid (2)
- Tuning Fork Set
- Resonance Air Column
- Mini Speaker
- Basic Optics System
- Precision Diffraction Slits
- Adjustable Focal Length Lens
- Red Diode Laser
- Polarization Analyzer
- Linear Translator
- PASPORT Absolute Pressure Sensor
- PASPORT Quad Temperature Sensor
- PASPORT High Sensitivity Light Sensor
- Red Banana Plug Cord (5 Pack)
- Radiation Cans
- Ideal Gas Law Apparatus



Electromagnetism

Electromagnetism Includes:

- Modular Circuits Set
- Modular Circuits Expansion Pack
- Wireless Charge Sensor
- Wireless Current Sensor Module
- Charge Producers and Proof Plane
- Faraday Ice Pail
- Conductive Spheres
- Electrostatics Voltage Source
- Field Mapper Kit
- Voltage Sensor (2)



In this parallel resistor experiment, the 550 Universal Interface is used as a DC power supply to measure both the output voltage and the voltage across the resistors. The Wireless Current Sensor Module is used in-line in the circuit to measure the current in each loop.

550 Universal Physics System Experiment Manual

UI-5831

This complete manual is included with the 550 Universal Physics System (UI-5830). Each experiment consists of student instructions in a Word® document that the instructor can modify as they like, a PASCO Capstone setup file ready for data collection, a Capstone file with sample data, and all the lab equipment required for the experiment. All of this content is provided on a flash drive.

Experiments:

- | | | |
|---|---|---|
| 1. Introduction to Measurement | 23. Work-Energy Theorem: Compare W to ΔE | 43. Reflection |
| 2. Uncertainty and Error Analysis | 24. Conservation of Momentum | 44. Refraction |
| 3. Graph Matching | 25. Impulse and Change in Momentum | 45. Dispersion |
| 4. Instantaneous and Average Velocity and Speed | 26. Ballistic Pendulum | 46. Focal Length of a Concave Mirror |
| 5. Motion with Constant Acceleration | 27. Newton's Second Law for Rotation | 47. Optical Instruments: Telescope and Microscope |
| 6. Equations of Motion for Constant Acceleration | 28. Rotational Inertia | 48. Variation of Light Intensity |
| 7. Acceleration Due to Gravity | 29. Rotational Kinetic Energy | 49. Light Intensity versus Distance |
| 8. Freefall of a Picket Fence | 30. Conservation of Angular Momentum | 50. Polarization: Verify Malus' Law |
| 9. Acceleration on an Inclined Track | 31. Oscillations of Cart and Springs | 51. Brewster's Angle |
| 10. Projectile Range vs. Launch Angle | 32. Physical Pendulum | 52. Diffraction of Light |
| 11. Newton's First Law | 33. Period of a Large Amplitude Pendulum | 53. Electrostatic Charges |
| 12. Newton's Second Law | 34. Archimedes' Principle - Buoyant Force | 54. Electric Field Mapping |
| 13. Force & Acceleration | 35. Transfer of Heat by Radiation | 55. Ohm's Law |
| 14. Inertia and Newton's Second Law | 36. Specific Heat | 56. Series and Parallel Circuits |
| 15. Newton's Third Law | 37. Boyle's Law: P and V of a Gas at Constant T | 57. Kirchhoff's Laws |
| 16. External Force and Newton's Laws | 38. Resonant Modes of Sound in a Tube | 58. RC Circuit |
| 17. Atwood's Machine | 39. Speed of Sound in Air | 59. General Properties of Diodes |
| 18. Friction and Newton's Laws | 40. Superposition of Sound Waves | 60. Magnetic Field Mapping |
| 19. Centripetal, Tangential, and Angular Acceleration | 41. Interference of Sound Waves | 61. Induction – Magnet Through a Coil |
| 20. Conservation of Energy on an Inclined Track | 42. Object and Image Distances for a Thin Lens | |
| 21. Hooke's Law | | |
| 22. Conservation of Energy for a Simple Pendulum | | |

Order Information

Universal 550 Physics Experiment Bundle.....	UI-5830B
Universal 550 Physics Experiment Manual	UI-5831
(included in UI-5830B)	
Required:	
550 Universal Interface	UI-5001

Mechanics Lab Stations

Physics Lab Station: Mechanics Starter

ME-5300

The Physics Lab Station: Mechanics Starter bundle is a lab-ready solution for performing several key experiments in mechanics. It includes a sensor-loaded Smart Cart, a durable PASTrack, and a variety of accessories that support student studies of core topics such as velocity, conservation of energy, and Newton's Second Law.

Real-Time Sensor Measurements

Students can use the Smart Cart's built-in sensors to make real-time measurements of position, velocity, acceleration, force, and rotation, displaying them as the lab unfolds for more meaningful learning. They can also collect and compare data from multiple trials, easily apply lines of fit, and perform statistical analysis using PASCO software.

Ready-Made Mechanics Labs

This kit is complemented by a collection of ready-made experiments that can be downloaded for free from the Experiment Library. Each lab comes ready-to-use with editable student handouts, teacher answer keys, and helpful teaching tips.

Perform These Experiments:

- ▶ Average Speed and Velocity
- ▶ Graphing Motion
- ▶ Speed and Velocity Graphs
- ▶ Conservation of Energy
- ▶ Work and Kinetic Energy
- ▶ Newton's Second Law
- ▶ Coefficients of Friction
- ▶ Momentum and Impulse
- ▶ Periodic Motion: Mass and Spring



Includes:

- | | |
|---------------------------------------|-------------------|
| • Smart Cart (red) | ME-1240 |
| • Smart Cart Rod Stand Adapter | ME-1244 |
| • Cart Mass (set of 2) | ME-6757A (2 sets) |
| • PASTrack | ME-6960 |
| • Aluminum Meter Stick | |
| • Dynamics Track End Stop (pair) | ME-8971 |
| • Small "A" Base with Leveling Feet | ME-8989 |
| • Stainless Steel Rod, 60 cm Threaded | ME-8977 |
| • Mass and Hanger Set | ME-8979 |
| • IDS Spring Kit | ME-8999 |
| • Super Pulley Kit | ME-9433 |
| • Angle Indicator | ME-9495A |
| • Multi-Clamp | ME-9507 |
| • Friction Block | ME-9807 |
| • Track Rod Clamp | ME-9836 |
| • Bumper Accessory Set | ME-9884 |



Order Information

Physics Lab Station: Mechanics Starter ME-5300
 Required:
 PASCO Capstone Software pp. 8-11
 OR
 SPARKvue Software pp. 12-13

Physics Lab Station: Mechanics Extension

ME-5301

The Physics Lab Station: Mechanics Extension bundle expands your physics toolbox, allowing students to explore topics such as statics, rotation, projectile motion, and periodic motion. It includes an additional Smart Cart for studying collisions, a Mini Launcher for firing projectiles, and a Wireless Smart Gate for timing events accurately. A variety of accessories are also included.

Real-Time Sensor Measurements

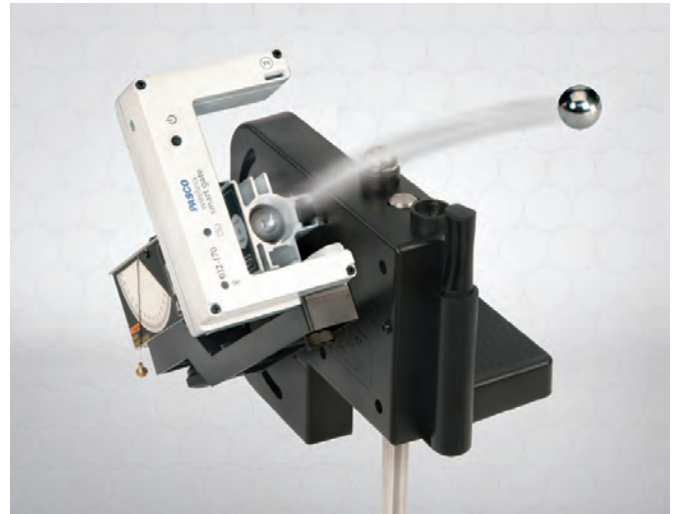
Students can use the Wireless Smart Gate and patented Smart Cart to monitor key measurements in real time, displaying them as the lab unfolds for more meaningful learning. Use the Smart Cart's built-in sensors to measure motion on or off the track, or time events with precision using the dual-beam Wireless Smart Gate. Students can also collect and compare data from multiple trials, easily apply lines of fit, and perform statistical analysis using PASCO software.

Ready-Made Mechanics Labs

This kit is complemented by a collection of ready-made experiments that can be downloaded for free from the Experiment Library. Each lab comes ready-to-use with editable student handouts, teacher answer keys, and helpful teaching tips.

Perform These Experiments:

- Conservation of Momentum
- Momentum and Explosions
- Simple Pendulum
- Atwood's Machine
- Two Dimensional Motion: Projectiles
- Exploring Torque
- Exploring a Rotating System
- Momentum and Impulse
- Exploring Physical Pendulums



Includes:

- | | |
|--------------------------------------|----------|
| • Smart Cart (blue) | ME-1241 |
| • Photogate Mounting Bracket | ME-6821A |
| • Mini Launcher | ME-6825B |
| • Pivot | ME-7034 |
| • Meter Stick Torque Mass Hanger Set | ME-7035 |
| • Photogate Pendulum Set | ME-8752 |
| • Pendulum Clamp | ME-9506 |
| • Photogate Wireless Smart Gate | PS-3225 |

Requires Physics Lab Station: Mechanics Starter (ME-5300) on page 76.



Order Information

Physics Lab Station: Mechanics Extension	ME-5301
Required:	
Physics Lab Station: Mechanics Starter.....	ME-5300
PASCO Capstone Software.....	pp. 8-11
OR	
SPARKvue Software	pp. 12-13

Fluids Lab Station

Physics Lab Station: Fluids

ME-2040

The Physics Lab Station: Fluids bundle enables students to perform several essential experiments in fluids. It includes a Wireless Pressure Sensor for making measurements of pressure in liquids and gases. A Density Set and Overflow Can are also included for measuring buoyant forces in fluids.

Real-Time Sensor Measurements

Students can use the Wireless Pressure Sensor to make real-time measurements of pressure in liquids or gases, displaying them as the lab unfolds for more meaningful learning. They can also collect and compare data from multiple trials, easily apply statistics, and export their data using PASCO software.

Ready-Made Fluids Labs

This kit is complemented by a collection of ready-made experiments that can be downloaded for free from the Experiment Library. Each lab comes ready-to-use with editable student handouts, teacher answer keys, and helpful teaching tips.

Perform These Experiments:

- ▶ Boyle's Law
- ▶ Hydrostatic Pressure
- ▶ Buoyant Force



Includes:

- | | |
|----------------------------|----------|
| • Wireless Pressure Sensor | PS-3203 |
| • Density Set | ME-8569A |
| • Overflow Can | SE-8568A |

Requires Physics Lab Station: Mechanics Starter (ME-5300) on page 76.

Order Information

Physics Lab Station: Fluids.....	ME-2040
Required:	
Physics Lab Station: Mechanics Starter.....	ME-5300
PASCO Capstone Software.....	pp. 8-11
OR	
SPARKvue Software.....	pp. 12-13

Physics Lab Station: Electricity and Magnetism

EM-3557

This lab-ready equipment set supports experiments in electricity and magnetism across all levels of physics. It includes Wireless Voltage, Current, and Magnetic Field Sensors, an Essential Physics Modular Circuits Kit, and an Electronic Components Kit.

Textbook Circuits for the Real World

The Essential Physics Modular Circuits Kit brings 2D circuitry to the real world, allowing students to study and measure circuits using components that look like textbook models. Each square piece displays both the physical component (resistor, capacitor, etc.) and the schematic to help bridge the gap between circuit diagrams and functioning circuits.

Real-Time Measurements

Students can use the Wireless Voltage and Current Sensors to make measurements anywhere in their circuit. Voltage and current readings are displayed in real time, allowing students to quickly compare and contrast different circuit configurations. They can also use PASCO software to collect and compare data, apply lines of fit, and perform statistical analysis.

Ready-Made Electricity & Magnetism Labs

This kit is complemented by a collection of ready-made experiments that can be downloaded for free from the Experiment Library. Each lab comes ready-to-use with editable student handouts, teacher answer keys, and helpful teaching tips.

Perform These Experiments:

- ▶ Ohm's Law
- ▶ DC Circuits
- ▶ Capacitors and RC Circuits
- ▶ Magnetic Field of a Permanent Magnet
- ▶ Electromagnetic Induction
- ▶ Magnetic Field in a Coil
- ▶ Planck's Constant



Includes:

- | | |
|--|----------|
| • Essential Physics Modular Circuits Kit | EM-3536 |
| • Wireless Current Sensor Module* | EM-3534 |
| • Wireless Voltage Sensor* | PS-3211A |
| • Wireless Magnetic Field Sensor | PS-3221 |
| • Electronic Components Kit | EM-8818 |

* Included with EM-3536

Order Information

Physics Lab Station: Electricity and Magnetism EM-3557

Required:

PASCO Capstone Software pp. 8-11

OR

SPARKvue Software pp. 12-13

Optics Lab Station

Physics Lab Station: Optics

OS-8910A

The Physics Lab Station: Optics bundle is a lab-ready solution for performing a wide range of optics experiments – from introductory investigations of lenses to advanced experiments in Snell's Law. It includes a Basic Optics Ray Table, a Light Source, Concave and Convex Mirrors, and various lenses and accessories. The included equipment mounts easily to a PASCO Dynamics Track or a 1.2m Optics Track (sold separately) for hassle-free alignment.

Ready-Made Optics Labs

This kit is complemented by a collection of ready-made experiments that can be downloaded for free from the Experiment Library. Each lab comes ready-to-use with editable student handouts, teacher answer keys, and helpful teaching tips.

Perform These Experiments:

- ▶ Spherical Mirror Reflection
- ▶ Snell's Law
- ▶ Focal Length of a Converging Lens
- ▶ Virtual Images
- ▶ Telescope and Microscope
- ▶ Shadows



Includes:

- | | |
|--|----------|
| • Concave/Convex Mirror | OS-8457 |
| • Basic Optics Viewing Screen | OS-8460 |
| • Basic Optics Ray Table | OS-8465A |
| • Basic Optics Light Source | OS-8470 |
| • Dynamics Track Optics Carriages (set of 4) | OS-8472A |
| • Basic Optics Geometric Lens Set | OS-8456 |
| • Accessory Lens Set | OS-8519 |

Requires either:

Physics Lab Station: Mechanics Starter (ME-5300) on page 76
or Optics Track (OS-8508) on page 294.



Order Information

Physics Lab Station: Optics	OS-8910A
Required:	
Physics Lab Station: Mechanics Starter	ME-5300
OR	
1.2. m Optics Track	OS-8508

Physics Lab Station: Waves and Sound

WA-9515

The Physics Lab Station: Waves & Sound bundle is a lab-ready solution for performing a variety of experiments in waves and sound. It includes a 2-in-1 Wireless Sound Sensor, a complete Tuning Fork Technical Set, a high-quality Resonance Air Column, and a Double-Length Slinky.

Real-Time Sensor Measurements

The Wireless Sound Sensor gives students unparalleled insight into the physics of sound and waves. Students can use the sensor to measure the frequency of a sound wave, and then visualize the waveform using PASCO software. Students can use the Double-Length Slinky to create a waveform with a partner, then use PASCO software to easily measure sound waves for further analysis.

Ready-Made Sound and Wave Labs

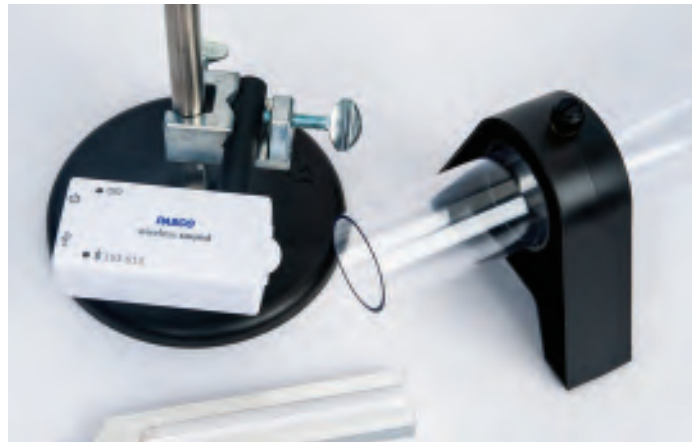
This kit is complemented by a collection of ready-made experiments that can be downloaded for free from the Experiment Library. Each lab comes ready-to-use with editable student handouts, teacher answer keys, and helpful teaching tips.

Perform These Experiments:

- ▶ Resonance and Standing Waves
- ▶ Properties of Sound Waves
- ▶ Measuring the Speed of Sound
- ▶ Decoding DTMF Tones

Includes:

- | | |
|-----------------------------|---------|
| • Wireless Sound Sensor | PS-3227 |
| • Tuning Fork Technical Set | SE-7728 |
| • Resonance Air Column | WA-9606 |
| • Double-Length Slinky | SE-8760 |



Order Information

Physics Lab Station: Waves and Sound WA-9515
 Required:
 PASCO Capstone Software pp. 8-11
 OR
 SPARKvue Software pp. 12-13

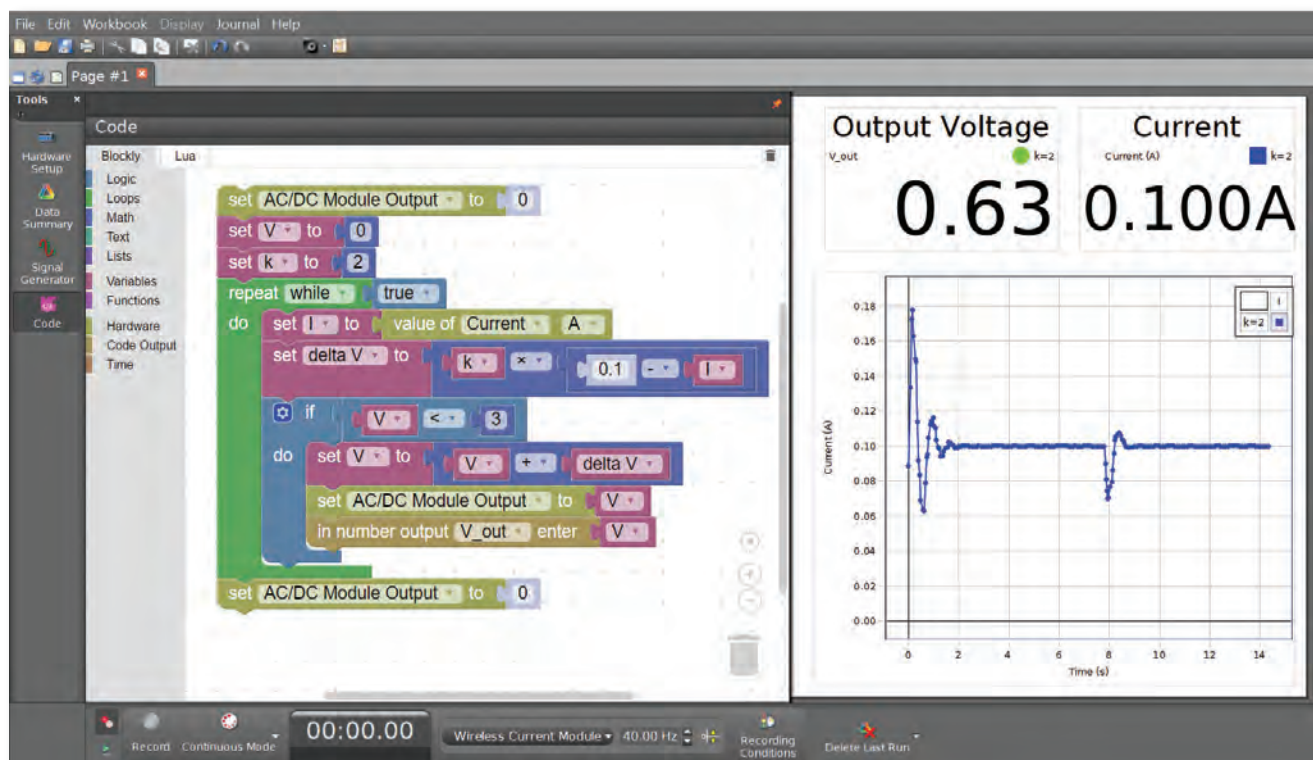
Sense & Control

Use PASCO Sensors, Output Devices, and Equipment to:

- Explore new applications with Blockly programming, available in PASCO Capstone™ and SPARKvue® software.
- Access all sensor readings through code, create feedback loops, and more.
- Use code to control outputs such as fans, signal generators, and motors.

How PASCO Makes Sense & Control Seamless

The integration of Blockly coding into our data collection software lets students use code to collect sensor data and control how devices respond to that data – all without having to download any drivers. Graph the output from your code in real time or display it using any Capstone display.



In PASCO Capstone, the Blockly code runs adjacent to a graph of the Current Sensor measurement, and a Digits Display shows output from the code.

Example: Construct a Constant Current Source

- Use the Modular Circuits (EM-3536) variable resistor, Wireless Current Module (EM-3534), and AC/DC Module (EM-3533).
- The voltage is adjusted in code to react when the resistive load is changed so as to keep the current constant.
- Use Capstone to record the current and voltage readings and view a graph of the current in real time as the code is executed.



Modular Circuits (pages 236-237)

Sense

- Use the Blockly integration in PASCO Capstone to code with any PASCO sensor or interface.
- Explore plug-and-play programming with PASPORT, ScienceWorkshop, and Wireless Sensors!



PASPORT Sensors (pages 31-47)



ScienceWorkshop Sensors (pages 26-30)



Wireless Sensors (pages 51-68)



//control.Node (page 68, 88)

Control

- New //control.Node (PS-3232) controls motors, fans, lights, and the PASCObot (PS-2994).



//control.Node
(page 68, 88)



PASCObot
(pages 96-101)

- Control the speed and direction of a Smart Fan (ME-1242) on a Smart Cart (ME-1240).



Smart Fan (page 113)

- Control the speed and direction of a Smart Cart Motor (ME-1247).



Smart Cart Motor (page 116)

- Activate motors, lights, and a coil in Modular Circuits (EM-3536) using the AC/DC Module (EM-3533).



AC/DC Modular (page 239)

- On the //code.Node (PS-3231), change the color of the LED light, the intensity of the LED array, and the frequency of the speaker output.



//code.Node (page 68, 85)

- Control the frequency and amplitude of the signal generator outputs on the 550 (UI-5001) and 850 (UI-5000) Universal Interfaces.



550 Universal Interface (page 23)



850 Universal Interface (page 20)

- Control the frequency and amplitude of the Function Generator (PI-8127).



Function Generator (page 274)

- Control when or where the ball is launched by a Smart Ballistic Cart Accessory (ME-1246).



Smart Ballistic Cart Accessory (page 114)

Coding and Control Devices

The //code.Node device has six sensors and four outputs, such as sound and light.

The //control.Node is a device for powering and controlling motors and lights.



STEM Sense Kits

Three kits using the //code.Node:

- Coding with Vehicle Sensor Technologies Kit (page 86)
- Coding with Sensors Technologies Kit (page 87)
- Coding with Sound & Light Sensor Technologies Kit (page 87)



Three Sense & Control kits using the //control.Node:

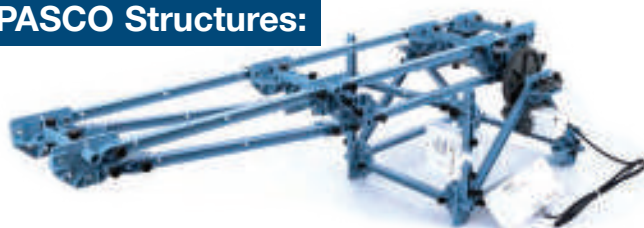
- Greenhouse Sense & Control Kit (page 92)
- //control.Node Sense & Control Kit (page 94)
- PASCObot Sense & Control Kit (page 97)



Motorized Structures Kits

Three kits using the //control.Node with PASCO Structures:

- Motorized Crane Kit (page 152)
- Motorized Drawbridge Kit (page 153)
- Robot Car Kit (page 154)



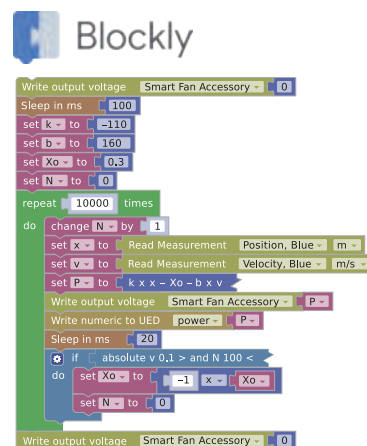
Student Activities and Teacher Resources



STEM Sense Kits make it easy to support students of all learning levels with a variety of scaffolding activities and open-ended challenges. Each lesson is based on the latest science standards and incorporates cross-curricular connections to reinforce key concepts in computer science, mathematics, and language arts.

Block-Based Programming

By embedding the Blockly coding tool into PASCO's Capstone and SPARKvue software, students get all the benefits of a visual coding environment combined with additional features for data collection, visualization, and analysis. When students execute a program in SPARKvue or Capstone, they can monitor sensor data in real time, displaying it in graphs, digits, and/or text.



//code.Node

PS-3231

The //code.Node is a turnkey coding solution that combines real-world sensor inquiry, Blockly coding, and live data displays to drive computational thinking in STEM learning. It includes six interactive sensors and four device outputs that measure and respond to phenomena using code created in SPARKvue or Capstone software.

Sensor Inputs:

- ▶ Temperature
- ▶ Motion
- ▶ Sound
- ▶ Light
- ▶ Magnetic Field

Device Outputs:

- ▶ Speaker
- ▶ RGB LED
- ▶ 5x5 LED array
- ▶ Software displays

**Applications:**

- ▶ Introduce computational thinking into science lessons.
- ▶ Explore science concepts using coding and data collection.
- ▶ Create a program to identify changes in your environment.
- ▶ Program songs, games, countdowns, alarms, and much more!

**Specifications:**

Maximum Sample Rate: 100 Hz

Light Level Sensor Range: 600 lx to 50,000 lx
(not calibrated)

Sound Level Sensor Range: 70 dB to 100 dB
(not calibrated)

Magnetic Field Sensor Range: ± 50 gauss

Acceleration Sensor Range: ± 8 g

Speaker Frequency Range: 10 Hz to 10,000 Hz

Ambient Temperature Sensor

Range: -25°C to 40°C

Resolution: 0.05°C

Accuracy: $\pm 1^{\circ}\text{C}$

Connectivity: USB and Bluetooth 5.1

Logging: No

Battery: Rechargeable LiPo

Includes:

- //code.Node
- USB Charging Cable

**Order Information**

//code.Node.....PS-3231

Also available:

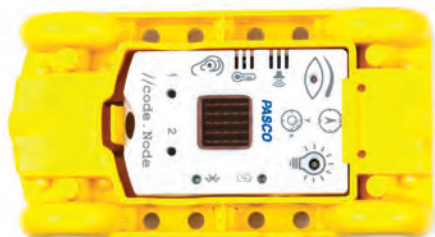
//code.Node Multi-Pack (set of 8)*PS-3311

* Includes 8 //code.Nodes, 8 holders, and 8 USB charging cables in storage box.

//code.Node Cart

PS-3235

- ▶ Built for use with a //code.Node
- ▶ //code.Node measures cart velocity
- ▶ Low-friction spring-loaded wheels
- ▶ Use with or without a dynamics track



The //code.Node snaps into the cart and detects the cart's velocity.

The //code.Node Cart is a four-wheeled cart into which fits the //code.Node. The //code.Node reads the velocity of the //code.Node Cart by detecting the spinning magnet on the cart axle. The low-friction wheels are spring-loaded to protect them if the cart falls off the table.

The //code.Node Cart is also useful without the //code.Node as a simple dynamics cart. A motion sensor can be used to track the motion of the cart..

Features:

- ▶ Low-friction spring-loaded wheels
- ▶ //code.Node snaps into cart
- ▶ //code.Node reads cart velocity
- ▶ Four slots for optional 50-gram masses
- ▶ Threaded hole for attaching bumpers
- ▶ String tie points on front and rear
- ▶ Designed to fit any PASCO dynamics track



//code.Node Cart with optional Light Spring Bumper



//code.Node Cart with //code.Node and optional masses and bumper

**Specifications:**

Mass of Cart: 100 g

Mass of Cart with //code.Node: 150 g

**Includes:**

- Cart Body with Wheels

Order Information

//code.Node Cart.....PS-3235

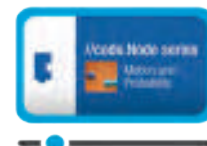
Coding with Vehicle Sensor Technologies Kit

ST-7820

Explore the science and sensors behind today's modern vehicles, while teaching students about physical science as they design, test, measure and code with sensors that mimic real-world vehicle technology.

**Activities & Video Lessons**

- ▶ **Crash Test:** Impact Alert System
- ▶ Investigating Odometers
- ▶ Engineering Turn Signals
- ▶ 3-2-1 Launch!
- ▶ **The Need for Speed:** Radar Detectors

**Build career awareness with activities that make real-world connections to:**

- ▶ Automotive engineering
- ▶ Real-life vehicle sensors
- ▶ Crash test engineering

Help students develop competency in:

- ▶ Problem-solving, logic, and critical thinking
- ▶ Computational thinking
- ▶ Data collection and analysis
- ▶ Mathematics
- ▶ Technology and programming

Coding with Vehicle Sensor Technologies Equipment

The Coding with Vehicle Sensor Technologies Kit comes classroom-ready with all the equipment, accessories, and software needed to complete the included activities. The complete kit includes a //code.Node; a //code.Node Cart; a color-printed booklet of student activities; two light spring bumpers; six 50-g masses; a 1.5-m roll of measuring tape; a spool of thread; and two block person figurines.

**Includes:**

- //code.Node PS-3231
- //code.Node Cart PS-3235
- Color-Printed Booklet of Student Activities
- Light Spring Bumper (qty. 2)
- 50 g Mass (qty. 6)
- Soft Measuring Tape, 1.5m
- Spool of Thread
- Block Person Figurine (qty. 2)

Order Information

Coding with Vehicle Sensor Technologies Kit.....ST-7820

Available Separately:

//code.Node Cart.....PS-3235

Coding with Sensor Technologies Kit

ST-7800

The Coding with Sensor Technologies Kit introduces students to foundational coding concepts and includes ten hands-on investigations that explore science phenomena using the //code.Node's programmable sensors, lights and sounds.



Activities & Video Lessons

- ▶ Magnetic Polarity
- ▶ Random Number Cube
- ▶ Automatic Night Light
- ▶ Light Bulb Efficiency
- ▶ Clap On
- ▶ What's the Origin?
- ▶ Investigating Sound Levels
- ▶ Step Counter
- ▶ Intruder Alarm
- ▶ Digital Thermometer

Build career awareness with activities that make real-world connections to:

- ▶ Engineering with real-life sensors
- ▶ Designing "smart" home technology
- ▶ Programming and developing sensor-based safety features

Help students develop competency in:

- ▶ Problem-solving, logical reasoning and critical thinking
- ▶ Computational thinking
- ▶ Data collection and analysis
- ▶ Mathematics
- ▶ Technology and programming

Coding with Sensor Technologies Equipment

The Coding with Sensor Technologies Kit includes a //code.Node, two painted bar magnets, a color printed booklet of student activities and a //code.Node Holder with wrist-strap.



Includes:

- //code.Node PS-3231
- //code.Node Holder PS-3233
- Painted Bar Magnet (pair) SE-7593
- Color-Printed Booklet of Student Activities

Coding with Sound and Light Sensor Technologies Kit

ST-7830

The Coding with Sound and Light Sensor Technologies Kit engages students in the exploration of light and sound with five hands-on coding investigations that use familiar phenomena and real-world sensors to bring concepts to life.



Activities and Video Lessons

- ▶ What is a Color Sensor?
- ▶ **RGB LED:** How to Program Color
- ▶ Engineering Sound Level Meters
- ▶ **Detect an Intruder:** Home Alarm Systems
- ▶ Investigating Electronic Tuners



Build career awareness with activities that make real-world connections to:

- ▶ Audio engineering and light technicians
- ▶ Programming and developing sensor-based security features
- ▶ Real-world innovations in sound and light technology

Help students develop competency in:

- ▶ Problem-solving, logic, and critical thinking
- ▶ Computational thinking
- ▶ Data collection and analysis
- ▶ Mathematics
- ▶ Technology and programming

Coding with Sound and Light Sensor Technologies Equipment

The Coding with Sound and Light Sensor Technologies Kit includes everything students need to explore concepts in light and sound through STEM. The complete kit includes: a //code.Node; a //code.Node Holder with wrist-strap; two tuning forks of different frequencies; a small flashlight; a color-printed booklet of student activities; a set of colored paper; and five sheets of aluminum foil.



Includes:

- //code.Node PS-3231
- //code.Node Holder PS-3233
- Color-Printed Booklet of Student Activities
- Small Flashlight
- Tuning Fork, Various Frequency (qty. 2)
- Colored Paper, Various 4"x4" Sheets (qty. 35)
- Aluminum Foil Sheet, 4"x4" Sheets (qty. 5)

Order Information

Coding with Sensor Technologies Kit.....ST-7800

Order Information

Coding with Sound and Light Sensor Technologies Kit.....ST-7830

//control.Node

//control.Node

PS-3232

- For controlling motors, fans, and pumps
- Program with Blockly code in PASCO Capstone or SPARKvue
- Sensor Port for sensors that provide information needed to control devices
- Record and view data from sensors while the devices are being controlled.
- Rechargeable battery provides power for the //control.Node and the devices plugged into it.
- Can upload code to the //control.Node and run autonomously (without connection to a computer)



The //control.Node has two ports for stepper motors, two ports for servo motors, and one port for sensors.

Winner of the 2022 Educators Pick
Best of STEM™: Engineering Award

The purpose of the //control.Node is to control devices such as stepper motors, servo motors, fans, and pumps. The //control.Node also provides battery power for these devices. The //control.Node wirelessly communicates via Bluetooth to a computer and it receives instructions written in Blockly code to control the devices. Code can be uploaded to the //control.Node and run autonomously without connection to a computer.

The //control.Node can also send sensor readings to the computer while executing code. These sensor readings can be used as feedback in the program and can also be displayed live in graphs and other displays in PASCO Capstone or SPARKvue. It has one sensor port for PASCObot Modules or the Greenhouse Sensor. It has a rechargeable battery and can be powered using the USB connection.

Built-in Features:

- Two Power Output Channels for Stepper Motors and Power Output Board
- Two Servo Ports for Regular Servos and Continuous Rotation Servos
- Accelerometer
- Speaker
- Sensor Port
- Rechargeable Lithium Ion Battery
- Bluetooth BLE Communication
- USB Port for Charging and Communication
- Two 6-32 Threaded Holes for Mounting

**Includes:**

- //control.Node
- USB Charging Cable

The //control.Node is used in the following kits:

- Motorized Drawbridge
- Robot Car
- Motorized Crane
- PASCObot Sense & Control Kit
- Greenhouse Sense & Control Kit
- //control.Node Sense & Control Kit

Because the //control.Node can be moved from one kit to another, it is only necessary to purchase one //control.Node to be able to do all the projects in these kits. Each kit can be purchased with or without the //control.Node.

Specifications:

Power Output Ports: ± 5 VDC, 0.7 A

Power Output Ports: Auto-ID stepper motors and Power Output Module

Power Output Ports: 8-pin modular jack

Servo Ports: Accepts standard servos and continuous rotation servos

Servo Ports: 3-pin connector

Servo Ports: Not auto-ID

Servo Ports: Built-in servo current sensor for detecting load

Sensor Port: I2C

Sensor Port: 6-pin modular jack

Acceleration Sensor: $\pm 16g$, 3-axis

Speaker Frequency Range: 10 Hz to 10,000 Hz

Dimensions: 11.5 x 5 x 3 cm

Mass: 142 g

Connectivity: USB and Bluetooth 5.2

Logging: No

Battery Type: Rechargeable LiPo

Order Information

//control.Node..... PS-3232

Stepper Motors

High Speed Stepper Motor PS-2976

Low Speed Stepper Motor PS-2978

This Low Speed Stepper Motor is geared down to rotate slower than the High Speed Stepper Motor (PS-2976). The Stepper Motors plug into one of the Power Output ports on the //control.Node using the included cable. The Stepper Motors can be set to rotate through a given angle or at a given speed with a resolution of 480 steps/revolution (0.75 degrees). The feedback loop that makes it go at a constant speed is contained within the //control.Node, so there is no delay while waiting for the computer to respond. The Stepper Motors monitor how far and how fast the motor moves using the //control.Node and PASCO Capstone or SPARKvue software.

The Stepper Motors can be mounted using the two 6-32 inserts included on its exterior. The conventional, 24-tooth spline and custom case match the form factor and attachment hole pattern of a Servo Motor, making it easy to substitute a Servo Motor for a Stepper Motor in your project designs. These Stepper Motors also include a hub with threaded holes that can be fitted onto the spline to securely mount accessories such as the PASCObot wheels, pulleys, or gears.

Specifications:

Spline: 24 tooth plastic

Voltage: 5 V

Connecting Cable:

8-pin modular plug

Mass: 70 g

Resolution: 0.75 deg/step

Hub Threaded Holes: 6-32

Maximum Rotation Speed: 2 rev/sec

Each Motor Includes:

- Stepper Motor
- Cable for connecting motor to //control.Node
- Hub with threaded holes for mounting accessories

Order Information

High Speed Stepper Motor.....	PS-2976
Low Speed Stepper Motor.....	PS-2978

Continuous Rotation Servo

SE-2977

This Continuous Rotation (non-proportional) Servo can rotate continuously in the same direction and is ideal for robotic applications.

Specifications:

Operating Voltage: 4.8 V to 6.0 V

No-Load Speed (6.0 V): 52 rpm

Dimensions: 40.6 x 19.6 x 36.6 mm

Mass: 41.7 g

Output Shaft Spline:

24 tooth

Includes:

- Hitec HSR-1425CR Servo
- Servo Horns (4)



Order Information

Continuous Rotation Servo.....	SE-2977
--------------------------------	---------

Power Output Module

PS-3324

- Blocky control over channel 1 or channel 2 for independent control of accessories



The Power Output Module supports additional connections to the //control.Node, enabling students to extend their engineering projects beyond the contents in their kit. Simply plug the Power Output Module into the //control.Node, attach your accessory to the Output Module, and start coding your project! The Power Output Module splits access to the //control.Node's battery power, enabling students to power motors, solenoids, switches, lights, and many other accessories using the Blockly programming integration available in SPARKvue and PASCO Capstone.

Specifications:

Connector: 16" 8-pin modular plug to the control node

Channels: 2 independently controlled sides of the board

Device Connector Options: 0.025" square post header, terminal block screw, USB

Current per Output Channel: 0.7A

Voltage: 5V

Dimensions: 3.7 x 5.7 cm

Includes:

- 8-pin modular plug to connect to the //control.Node

Order Information

Power Output Module	PS-3324
---------------------------	---------

Servo Motor

SE-2975

This standard Servo Motor plugs into one of the two server ports on the //control.Node (PS-3324). The motor rotates through 180 degrees, moving a push rod that rotates a part, such as the aileron on an airplane.

Within the //control.Node is an internal current sensor that monitors the Servo Motor Ports, making it easy for students to know when a load is placed on the servos. When the servos on the PASCObot Gripper (PS-3325) start to draw more current, the code can detect that an object has been gripped and determine how hard the object is being squeezed.

Specifications:

Operating Voltage: 4.8 V to 6.0 V

Output Torque: 3.3 kg-cm at 4.8 V

Current Draw at Idle: 8 mA

No Load Operating

Current Draw: 150 mA

Stall Current Draw: 800 mA

Dimensions: 40.6 x 19.8 x 36.6 mm

Mass: 45.5 g

Motor Type: 3 Pole Metal

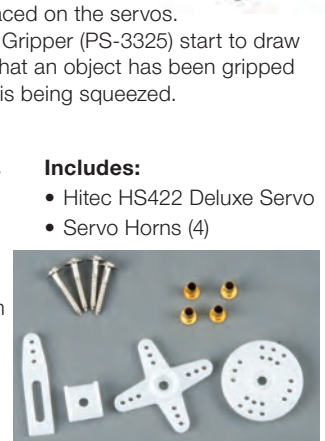
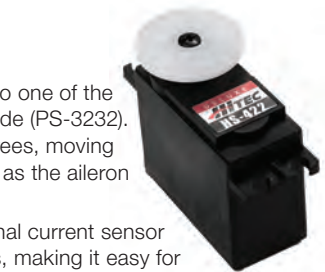
Brush Ferrite

Gear Material: Nylon

Output Shaft Spline: 24 tooth

Includes:

- Hitec HS422 Deluxe Servo
- Servo Horns (4)



Order Information

Servo Motor.....	SE-2975
------------------	---------

//control.Node Sensors

//control.Node Voltage Sensor

PS-3349

This general purpose voltage sensor plugs into the Sensor port on the //control.Node. The sensor readings are transmitted via Bluetooth by the //control.Node.

The Voltage Sensor has two input ports for analog voltages, two input ports for digital voltages that return a 1 or 0, and two push-buttons that return a 1 when pushed. Each of the analog and digital ports has a 5 V DC output pin to power home-made sensors or Arduino-type sensors that can be purchased elsewhere. For a list of compatible sensors, see the list on the Documents tab.

Each of the inputs has two ways to connect to wires:

- **3-pin male connector:** Slide with the included female-to-male wires onto each pin or use a female 3-pin connector to 3 wires.
- **Push-button connector block:** Push the button and insert a bare wire, then release the button.
- There are also two green LEDs which can be activated using Blockly programming in PASCO Capstone or SPARKvue. All the voltage inputs and the push-buttons are also available to be used in Blockly.

Specifications:

Analog Voltage Range: +/- 15 V

Maximum Sample Rate: 50 Hz

Cable to Connect to //control.Node Sensor Port: 6-pin male-to-male modular cable to the control node (18 inches long)

Jumper Wires: 20 cm long, tinned on both ends, 4 each of 3 colors

Power Out Pin: +5 V DC

Product Push-Button Connector Blocks: Four 3-slot blocks

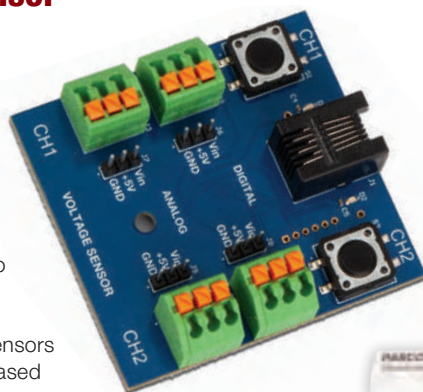
Connector Pins: Four 3-pin headers

Push-Buttons: 2 momentary buttons

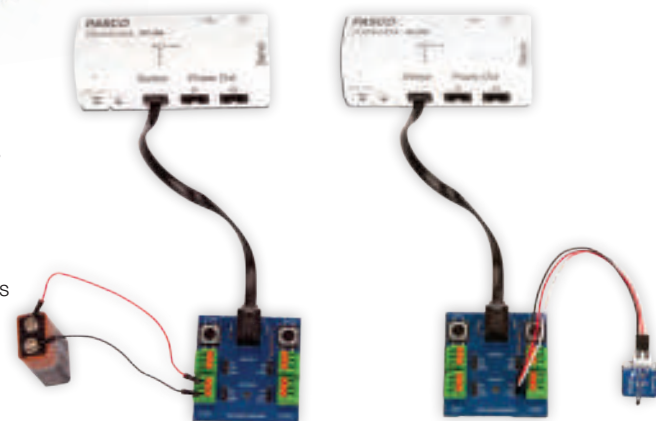
LEDs: 2 green LEDs

Includes:

- Voltage Sensor Board
- Cable to connect Voltage Sensor Board to the //control.Node sensor port
- Jumper wires, male-to-female, various colors, 6 inches (15 cm) long (qty. 20)

**Applications:**

- ▶ Measure analog voltages.
- ▶ Power a photogate and detect when the beam is interrupted.
- ▶ Detect when a limit switch has been activated.
- ▶ Make your own analog sensor, powered by 5 V.
- ▶ Detect when a button is pushed.
- ▶ Measure voltage of a solar cell.
- ▶ **Create a reaction timer:** Use Blockly to program the LED to randomly light up and then time how long it takes until the button is pushed.

**Features:**

- ▶ Two digital inputs
- ▶ Two analog voltage inputs
- ▶ Two push-buttons
- ▶ Two white LEDs
- ▶ Connects to the Sensor Port on the //control.Node
- ▶ Powered by the //control.Node
- ▶ Programmable with Blockly in PASCO Capstone or SPARKvue
- ▶ Connect to inputs with 3-pin header or push-button terminal block
- ▶ 5 V pin available to power sensors
- ▶ Compatible with many Arduino-type analog sensors

Order Information

//control.Node Voltage Sensor PS-3349

Limit Switch

PS-3351

This Limit Switch is used to limit the motion of Motorized Structures. The Limit Switch is plugged into a digital input on the //control.Node Voltage Sensor (PS-3349) which is plugged into the Sensor Port on the //control.Node (PS-3232). When the Limit Switch is activated by pressing up against an object, the Voltage Sensor detects a change in state. The Limit Switch state can be read and programmed in Blockly coding in Capstone or SPARKvue to cause motion to stop or start.

Includes:

- Limit Switch wired to a female 3-pin header
- Screws to connect the Limit Switch to a Limit Switch Holder or Turntable (2)

**Limit Switch Holder**

PS-3343

The Limit Switch Holder slides onto any PASCO Structures I-beam to any position along the length of the beam and is held in place by a thumbscrew. The Limit Switch is attached to a rod that slides into the Limit Switch Holder and is secured with a thumbscrew. The Holder is adjustable so the I-beam can be rotated to any orientation about the long axis of the I-beam and then can be secured in place with a thumbscrew. In this way, it is possible to orient the Limit Switch in any direction that is required to activate it. The user can choose to mount the Limit Switch rod parallel or perpendicular to the I-beam.

Includes:

- Limit Switch Holder to connect to a PASCO Structures I-beam
- Rod for connecting the Limit Switch to the Limit Switch Holder
- Screws to connect the Limit Switch to the rod (2)

**Order Information**

Limit Switch Holder..... PS-3343

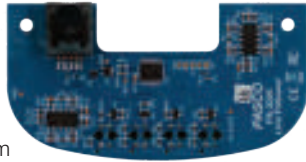
Order Information

Limit Switch PS-3351

PASCObot Line Follower Module

PS-3320

This module uses infrared light to detect the presence of black or white surfaces beneath the PASCObot. Using clever programming, students can program the PASCObot to follow (or avoid) black or white lines and/or surfaces, and much more!



The shape of the module is specific to the PASCObot, allowing the module to fit neatly inside the front of the bot, exposing the four infrared detectors on the module through the bottom of the bot body. With the included cable, students connect the module to the //control.Node allowing them to conduct sense and control experiments with the bot, of their own creation!

NOTE: The PASCObot Line Follower Module cannot be used simultaneously with the PASCObot Range Finder Module since both occupy the same slot in the PASCObot.

Specifications:

Infrared LED Array:
4 phototransistors

Includes:

- PASCObot Line Follower Module
- Cable to connect the module to //control.Node
- 4-40 x 7/16" screw for mounting the module to the PASCObot body (2)

Order Information

PASCObot Line Follower Module PS-3320

PASCObot Range Finder Module

PS-3321

This module uses Lidar to measure the distance between the PASCObot and objects in front of it. Using clever programming, students can program the PASCObot to approach (or avoid) these objects, and much more!



The shape of the module is specific to the PASCObot, allowing the module to fit neatly inside the front of the bot, exposing the lidar transceiver through a small hole in the front of the PASCObot. With the included cable, students connect the module to the //control.Node allowing them to conduct sense and control experiments with the bot, of their own creation!

NOTE: The PASCObot Range Finder Module cannot be used simultaneously with the PASCObot Line Follower Module since both occupy the same slot in the PASCObot.

Specifications:

Range: < 1m

Resolution: 2 mm

Includes:

- PASCObot Range Finder Module
- Cable to connect the module to //control.Node
- 4-40 x 7/16" screw for mounting the module to the PASCObot body (2)

Order Information

PASCObot Range Finder Module..... PS-3321

Greenhouse Sensor

PS-3322

- ▶ Determine abiotic growth factors in growing environments
- ▶ Follow light, humidity, and temperature from the mounted PC board placed inside the greenhouse
- ▶ Determine soil moisture levels using the capacitance of the soil around the moisture sensor

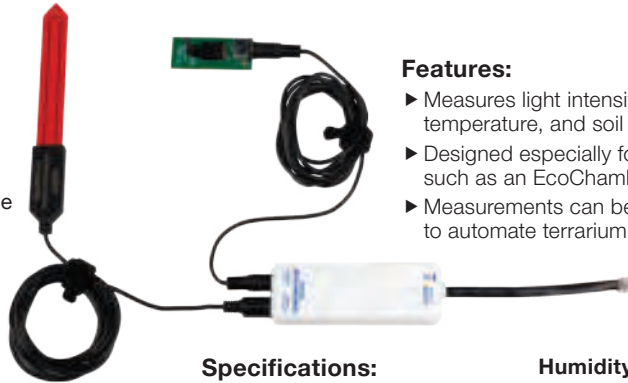
The Greenhouse Sensor measures the light intensity, atmospheric humidity, ambient temperature, and soil moisture inside a terrarium or closed environment. Designed for use with PASCO's Greenhouse Sense and Control Kit (PS-2997), the Greenhouse Sensor provides students with the real-time data they need to monitor conditions, chart patterns, and optimize their terrarium for sustained growth.

With the Greenhouse Sensor, students can monitor terrarium conditions in real time, displaying measurements as digits, tables, or graphs within SPARKvue or PASCO Capstone on their personal devices. Greenhouse Sensor measurements can also be used in custom Blockly programs to automate plant care, while teaching students about the role of coding and technology in modern agricultural monitoring.

Monitor, study, and automate terrarium conditions by adding a //control.Node and accessory, such as the Grow Light (PS-3347), the USB Fan (PS-6206), or the USB Pump (SE-6208).

Includes:

- Light, temperature, and humidity sensing pc board for mounting in greenhouse with 2m 4pin cable
- Capacitive soil moisture sensor with 2m cable
- Signal processing sensor box for communicating with the //control.Node via 6" cable



Features:

- ▶ Measures light intensity, humidity, temperature, and soil moisture
- ▶ Designed especially for contained spaces, such as an EcoChamber or terrarium.
- ▶ Measurements can be used as code input to automate terrarium conditions.

Specifications:

Operating Temperature:

-40°C to 80°C

Light Level Sensor:

Wavelength Range:

Visible Spectrum
(400 to 700 nm)

Range: Approximately 600 to 50,000 lx (not calibrated)

Resolution: 1 lx

Accuracy: 5%

Light Level Report Out: 0% to 100% of max reading

Ambient Temperature:

Range: -40°C to 80°C

Resolution: 0.01°C

Accuracy: ±0.5°C

Humidity:

Range: 0% to 95% non condensing

Resolution: ±0.02%

Accuracy: ±3%

Temp, Light, & Humidity Sensor Power Use: 0.98 mA at 3.3 V DC

Soil Moisture:

Range: 0% to 45%

Resolution: 0.1%

Accuracy: ±5%

Power Use: 3 mA at 5 V DC

Probe Cable Length: 2 m

Logging: No

Battery Type:

Rechargeable LiPo

Order Information

Greenhouse Sensor..... PS-3322

Greenhouse Sense & Control Kit

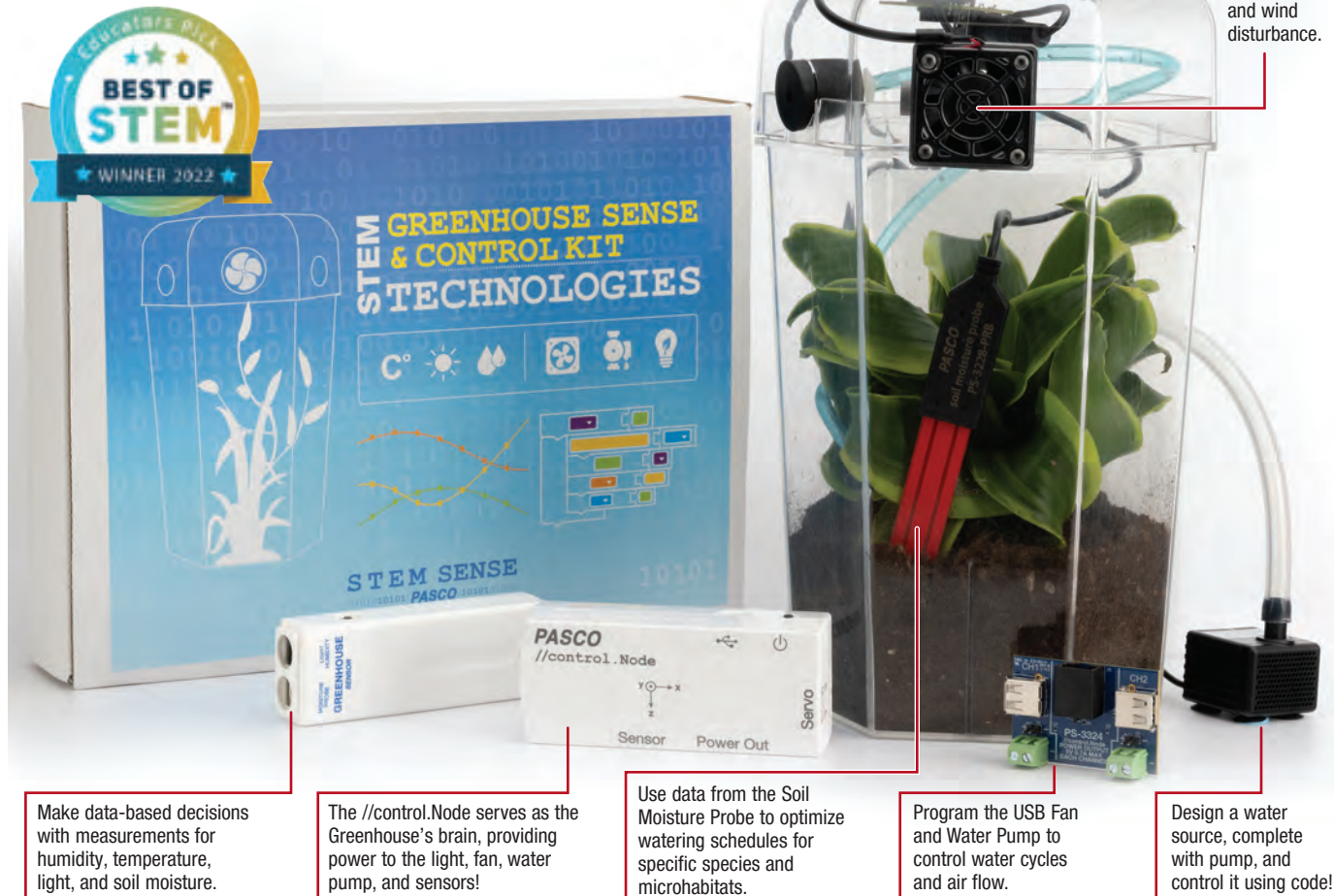
Greenhouse Sense & Control Kit

ST-2997

Designed for the exploration of biological concepts, the Greenhouse Sense & Control Kit includes everything students need to design, build, program, and study their very own greenhouse.

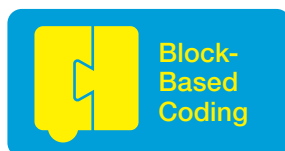
Ideal for studies in biology, environmental science, and STEM, the Greenhouse Sense & Control Kit comes fully customizable, enabling students to explore countless interactions between plants and environmental factors.

Potential topics of study include soil moisture, humidity, temperature fluctuations, light availability, inter- and intraspecies competition, wind disturbance, and so much more.



Applications:

- Study and control greenhouse conditions.
- Use code to automate light and watering schedules.
- Identify patterns over time with continuous data logging.
- Includes equipment and accessories, as well as five student activities.



Includes 5 Student Activities:

- Program a Sunny Day for Plants
- Code a Cooling Breeze for a Greenhouse
- Program Perfectly Timed Rain
- Optimize Water Movement in a Greenhouse
- Program a Greenhouse Sense and Control System

PASCO Grow Light

PS-3347

The PASCO Grow Light connects via USB to help keep classroom terrariums green and growing. Plug the Grow Light into a standard USB port to provide plants with consistent lighting, or connect it to a //control.Node to take full control. When powered by the //control.Node, the PASCO Grow Light becomes fully programmable, enabling students to control the light's intensity, color, and schedule.

When connected to a //control.Node, the red and blue LEDs can be controlled using Blockly code, available in both SPARKvue and PASCO Capstone.

USB Power

Control Port for
//control.Node



Specifications:

Red LED Peak Wavelength: 660 nm

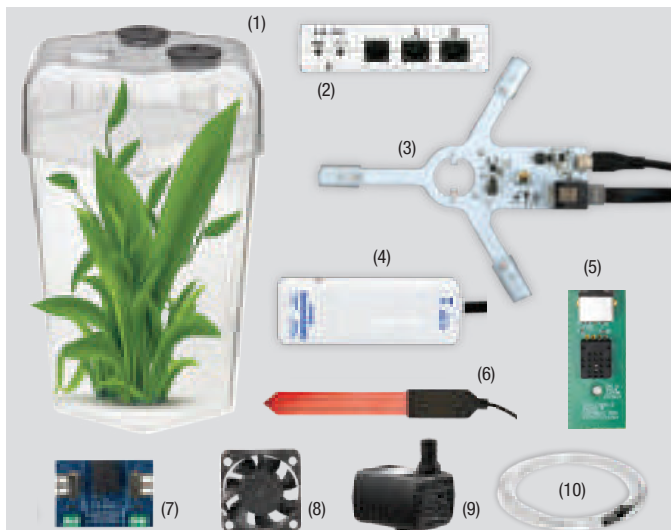
Blue LED Peak Wavelength: 445 nm

Red LED Peak Power: 1 W

Blue LED Peak Power: 3 W

Control Levels: 1-10 via Blockly

LED Control: Red and Blue controlled independently via Blockly



The Greenhouse Sense & Control Kit Includes:

- (1) EcoChamber (ME-6667)
- (2) //control.Node (PS-3232)
- (3) PASCO Grow Light (PS-3347)
- (4) Greenhouse Sensor (PS-3322)
- (5) Humidity/Light/Temp Probe
- (6) Soil Moisture Probe
- (7) Power Output Module (PS-3324)
- (8) USB Fan (PS-6206)
- (9) USB Water Pump (SE-6208)
- (10) Tubing with drip-watering ends

Order Information

Greenhouse Sense & Control Kit.....	ST-2997
Greenhouse Sense & Control Kit (without //control.Node)	ST-2998
Available Separately:	
Greenhouse Sensor.....	PS-3322
PASCO Grow Light	PS-3347

//control.Node Sense & Control Kit

//control.Node Sense & Control Kit

PS-5050

The //control.Node Sense and Control Kit empowers students to create and explore through code. This kit includes a //control.Node and accessories that students can use to turn on lights, run a cooling fan, open doors, launch rubber bands, and much more. The kit also includes materials and instructions for six projects:

- ▶ Night Light
- ▶ Game with a Meter
- ▶ Automatic Door Opener
- ▶ Thermostat-Controlled Fan
- ▶ Light-Activated Winch
- ▶ Remote Control Rubber Band Launcher

Night Light Project

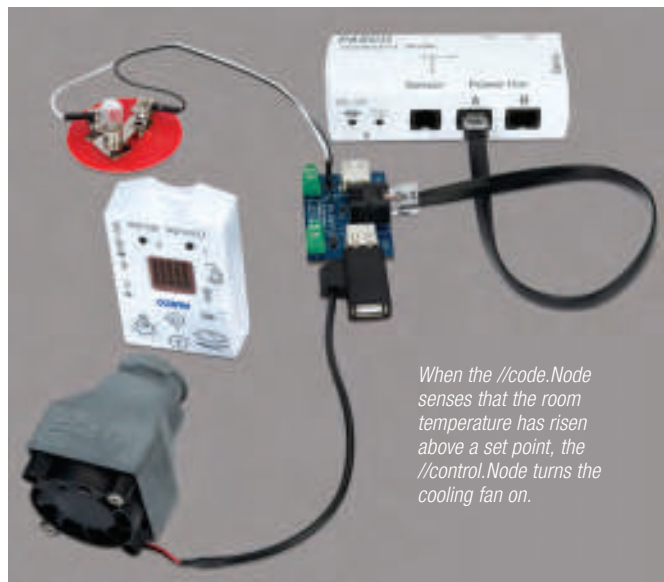
Goal: Construct a night light that automatically turns on when the room goes dark and turns off when the room is lit.



Night Light Project using the //control.Node and //code.Node

Thermostat-Controlled Fan Project

Goal: When the temperature rises above a specified point, turn on the fan, which cools the air by blowing into a wet cloth. When the temperature falls below a specified point, the fan turns off.



When the //code.Node senses that the room temperature has risen above a set point, the //control.Node turns the cooling fan on.

These projects use elements of the engineering design process:

- ▶ Define the problem.
- ▶ Research solutions.
- ▶ Design a prototype.
- ▶ Test a solution.
- ▶ Iterate and improve design.

Game with a Meter

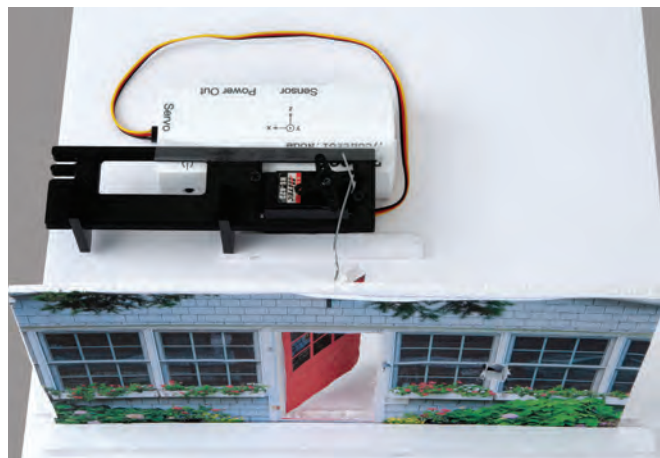
Goal: Make a meter that uses a stepper motor to rotate the indicator proportional to a sensor reading. Design a game that uses the meter to determine the outcome.



A stepper motor rotates the meter indicator to match the angle at which the //code.Node is tilted.

Automatic Door Opener Project

Goal: Build a house with a door. Push Button #1 on the //code.Node and the servo opens the door. Push Button #1 again and the servo closes the door.



The front of a house is constructed from foam core and the servo rod is attached to the door, allowing it to be opened and closed.

Light-Activated Winch Project

Goal: Place a white cup in front of a //code.Node with its light turned on. The reflected light triggers the winch to go down and the permanent magnet sticks to the object, hauling it up. Stop the winch when the cup is lifted above the //code.Node.



Light reflected from the cup triggers the winch to lower.

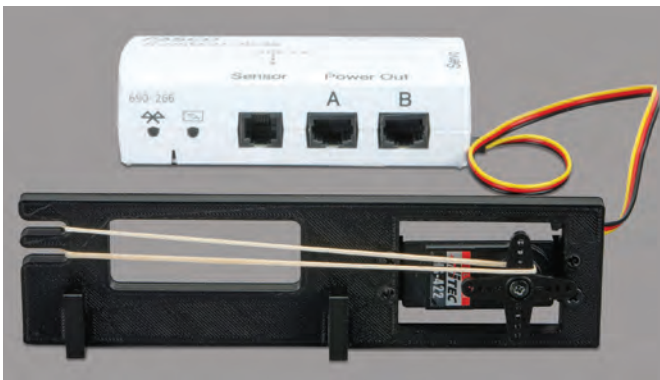
The winch picks up the cup.



Automatic Rubber Band Launcher Project

Part 1 Goal: Program the servo motor to hold its position while the rubber band is loaded. Push the button on the //code.Node to fire the rubber band.

Part 2 Goal: Expand on Part 1 by launching the rubber band when you clap your hands near the //code.Node's sound sensor. Use the //code.Node as a target, so that when the rubber band knocks it over, its accelerometer detects the motion, causing the //code.Node to flash its lights and sound an alarm.



Launch a rubber band when you clap your hands.



//control.Node Sense & Control Kit Includes:

- //control.Node (PS-3232)
- //code.Node (PS-3231)
- Servo Motor (SE-2975)
- High Speed Stepper Motor (PS-2976)
- USB Fan (PS-6206)
- Lightbulbs and Stands (EM-9099)
- Motor Bracket and Stand
- Power Output Module (PS-3324)
- Small Magnet
- Pulley
- Electrical Wires (2)
- Rubber Bands (10)
- Jumbo Paper Clips for Servo Pushrods (10)
- Mounting Bolts and Nuts for Motors
- House and Meter Paper Templates
- Phillips Screwdriver

Order Information

//control.Node Sense & Control Kit..... PS-5050

Sense & Control Kit without //control.Node

PS-5051

This kit is intended for courses that already have a //control.Node. The kit is identical to PS-5050 except it does not include a //control.Node (PS-3232).

Order Information

Sense & Control Kit without //control.Node.....PS-5051

PASCObot

PASCObot

PS-2994

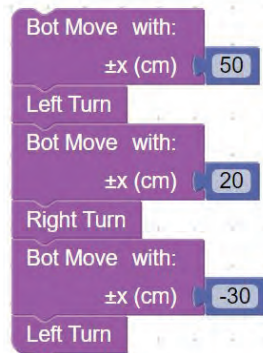
- Learn to code
- Simple operation
- Expandable for limitless learning
- Compatible with PASCO sensors

The PASCObot includes everything students need to assemble the robot, including the //control.Node, two stepper motors with wheels, and the car body. Assembled in minutes, the PASCObot's unique modular design makes swapping components easy, enabling students to use the //control.Node and stepper motors in additional projects outside the PASCObot.

Using Blockly coding within SPARKvue or PASCO Capstone, students can command the PASCObot to move forward or backward, make turns, and navigate mazes. After creating their program, students can command the PASCObot to execute the code in real-time, or store it onboard the //control.Node to be run autonomously at the push of a button.



The //code.Node can ride in the PASCObot and be programmed to make turn signals on the LED array.



Confident coders can control the two stepper motors independently to create turns and movements forward and backward. New programmers can choose from a variety of prepared Blockly code blocks to simplify more complex commands, like moving and turning the bot.



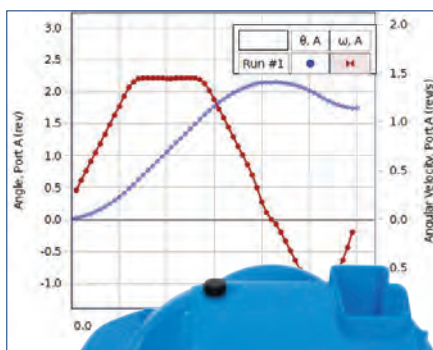
Students can assemble the PASCObot in minutes, putting together only seven parts, compared to the hundreds of parts in other robot kits.



Since the Blockly coding environment is embedded in SPARKvue and PASCO Capstone, students can program the PASCObot's movements alongside graphs of the motion data coming from the PASCObot's stepper motors and onboard acceleration sensor.

The PASCO Code Library (available in PASCO Capstone and SPARKvue) supports new coders with a collection of prepared Blockly code blocks designed specifically for use with the PASCObot.

The PASCObot's functionality can be easily expanded by placing a //code.Node in the top slot and integrating it into programs. Use the //code.Node as a remote control for the PASCObot by programming the PASCObot to turn when the //code.Node is tilted, or use the PASCObot with any PASCO sensor connected to a computer via Bluetooth. Learn without limits with PASCObot!



Execute code and produce motion data with PASCObot.

The PASCObot is more than just a robot. As students run their code, a real-time display of the bot's speed and distance can be viewed alongside the robot's motion. This feedback helps inform students when debugging their code and makes it easier for students to assess the effects of their code when it is executed.



The PASCObot is available with or without the //control.Node.

Includes:

- PASCObot Body PS-3318
- High Speed Stepper Motor (2) PS-2976
- PASCObot Wheel with Tire (set of 2) PS-3319
- //control.Node PS-3232
- Small #1 Phillips Screwdriver
- PASCObot Assembly Hardware

Order Information

PASCObot	PS-2994
PASCObot (without //control.Node)	PS-2995
Required:	
PASCO Capstone Software	pp. 8-11
OR	
SPARKvue Software	pp. 12-13

PASCObot Sense & Control Kit

ST-7840

The PASCObot Sense & Control Kit helps harness students' interest in robotics to drive deeper learning in science and STEM. This complete kit includes a PASCObot, //control.Node, and accessories, as well as digital activities to support students' coding journey.

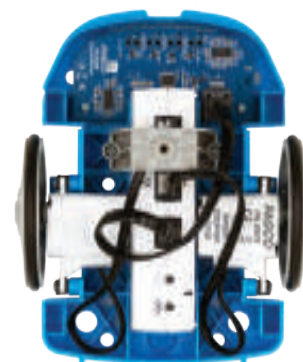
Sense and Control with PASCObot

Simple to build and easy to program, the PASCObot consists of just six pieces, including a PASCObot Body, two Wheels, two Stepper Motors, and a rechargeable //control.Node that enables students to execute their code in real time, or store it onboard for execution later.

With PASCObot, students can go beyond basic robotics applications, combining PASCO's real-time data collection, graphing, and analysis system with an intuitive coding interface that scales to their skill level. From programming the bot's first movements to navigating obstacle courses to head-to-head competitions – there's no limit to what students can do with PASCObot!



Mount accessories like the Line Follower Module (included) in the PASCObot to expand your sense & control capabilities.



See pages 98-101 for details about the contents of this kit.

Includes:

- PASCObot Body PS-3318
- High Speed Stepper Motor (2) PS-2976
- PASCObot Wheel with Tire (2) PS-3319
- //control.Node PS-3232
- PASCObot Line Follower Module PS-3320
- PASCObot Range Finder Module PS-3321
- PASCObot Gripper Accessory PS-3325
- Servo Motors (2) PS-2976
- PASCObot Line Follower Tape (one roll black, one roll white) SE-2953
- Colored Plastic Cup Set (set of 5) SE-2952
- Small #1 Phillips Screwdriver
- PASCObot Assembly Hardware

Order Information

PASCObot Sense & Control Kit.....	ST-7840
PASCObot Sense & Control Kit (without //control.Node)	ST-7841
Required:	
PASCO Capstone Software.....	pp. 8-11
OR	
SPARKvue Software	pp. 12-13

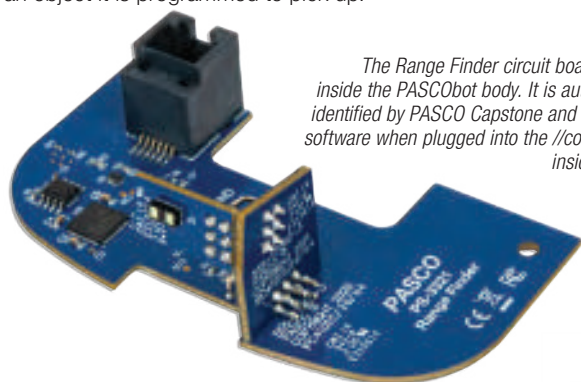
PASCObot Range Finder

PASCObot Range Finder Module

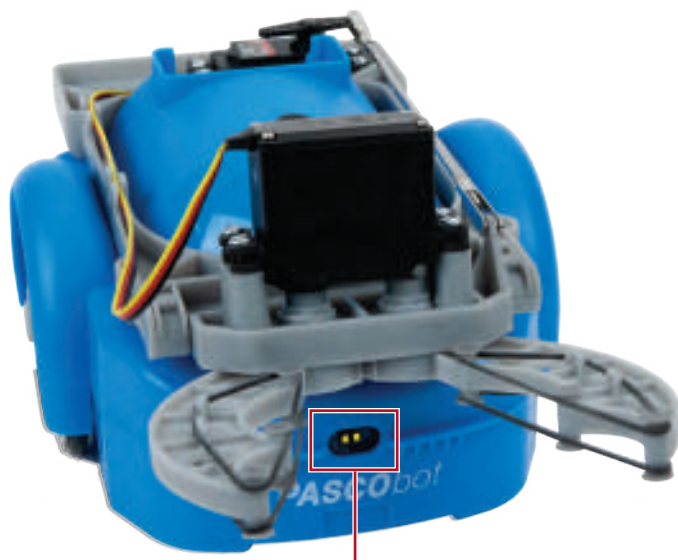
PS-3321

- Lidar range detector
- Detects objects closer than one meter

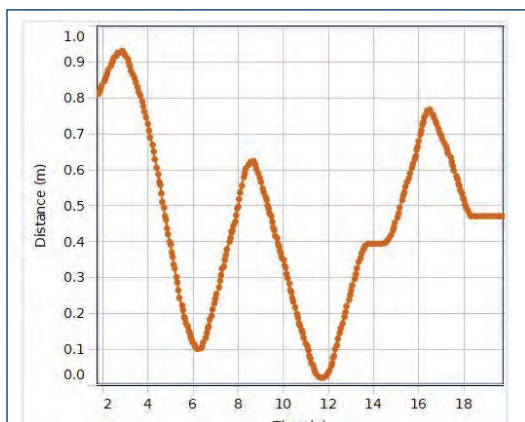
The Range Finder Module enables students to program how the PASCObot interacts with objects. A Lidar sensor on the circuit board uses infrared light to detect how far away objects are from the PASCObot, allowing students to program the bot to avoid or hit objects. The accessory offers enhanced features when used with the PASCObot Gripper, enabling the bot to detect the distance of an object it is programmed to pick up.



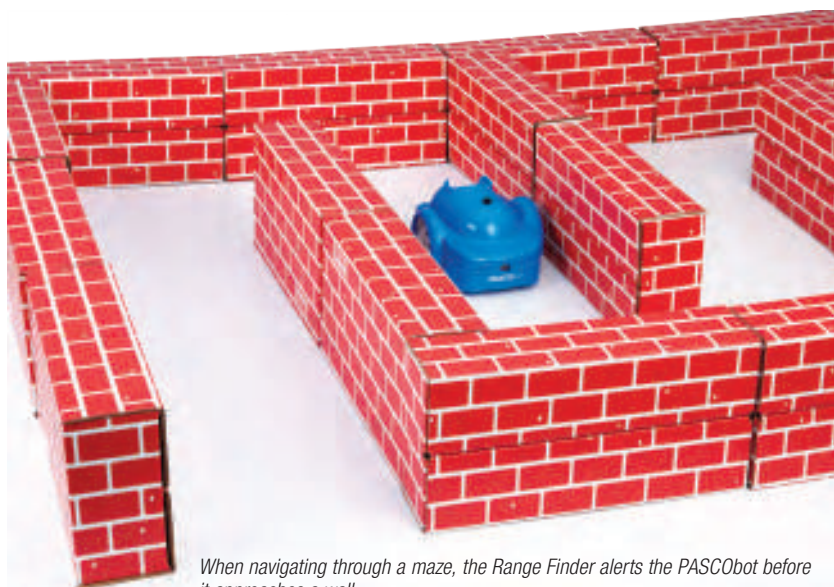
The Range Finder circuit board mounts inside the PASCObot body. It is automatically identified by PASCO Capstone and SPARKvue software when plugged into the //control.Node inside the bot.



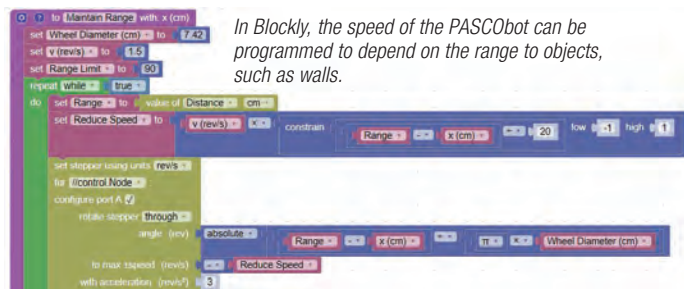
The Range Finder Lidar infrared emitter/detector pair peeks through a hole in the front of the PASCObot.



Distance data streams from the Range Finder to student devices, so students can see what the bot is seeing and interpreting.



When navigating through a maze, the Range Finder alerts the PASCObot before it approaches a wall.



In Blockly, the speed of the PASCObot can be programmed to depend on the range to objects, such as walls.

Note that the Range Finder cannot be used simultaneously with the Line Follower since both occupy the same slot in the PASCObot.

Includes:

- PASCObot Range Finder Module
- Cable to connect the module to //control.Node
- 4-40 x 7/16" screw for mounting the module to the PASCObot body (2)

Order Information

PASCObot Range Finder Module.....	PS-3321
Required:	
PASCObot	PS-2994
PASCO Capstone Software	pp. 8-11
OR	
SPARKvue Software	pp. 12-13
Recommended:	
PASCObot Gripper Accessory	PS-3325

PASCObot Gripper Accessory

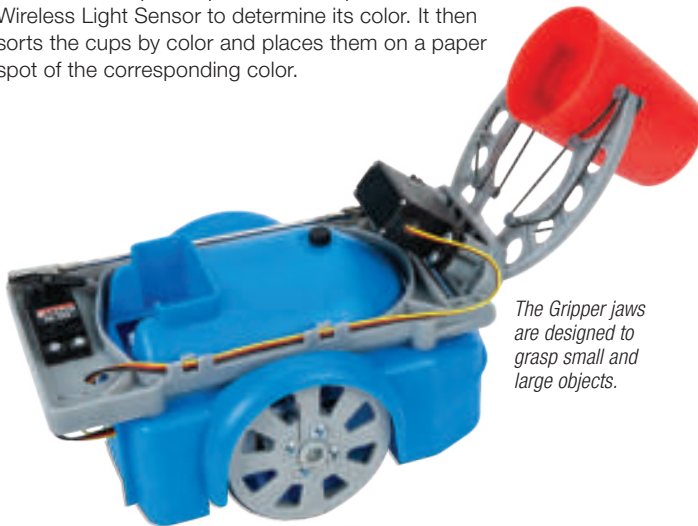
PS-3325

The Gripper Accessory brings a new range of motion to the PASCObot, enabling students to program the bot to lift, move, or stack objects.

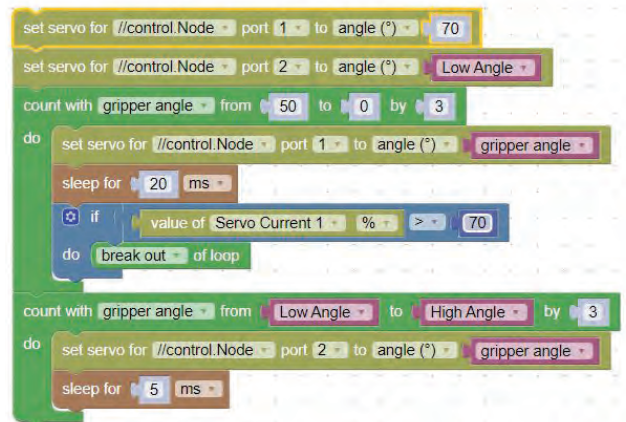
The Gripper mounts to the PASCObot, where its motion is controlled by servo motors that can be programmed to make the bot grasp and move objects.

Power is supplied and monitored by the rechargeable //control.Node, which has an internal current sensor for the servo motor ports. When the servos on the PASCObot Gripper begin to draw more current, the current sensor detects the load, and the Gripper closes onto the object. This unique feature also makes it possible for the code to recognize that an object has been gripped and determine how hard the Gripper is squeezing it.

The Gripper's functionality is most robust when used with the Range Finder Module. When the Range Finder detects the bot's distance to an object, student code moves the PASCObot up to the object, and the Gripper squeezes around the object, lifting it up. In one activity, the PASCObot picks up a colored cup and takes it to a Wireless Light Sensor to determine its color. It then sorts the cups by color and places them on a paper spot of the corresponding color.



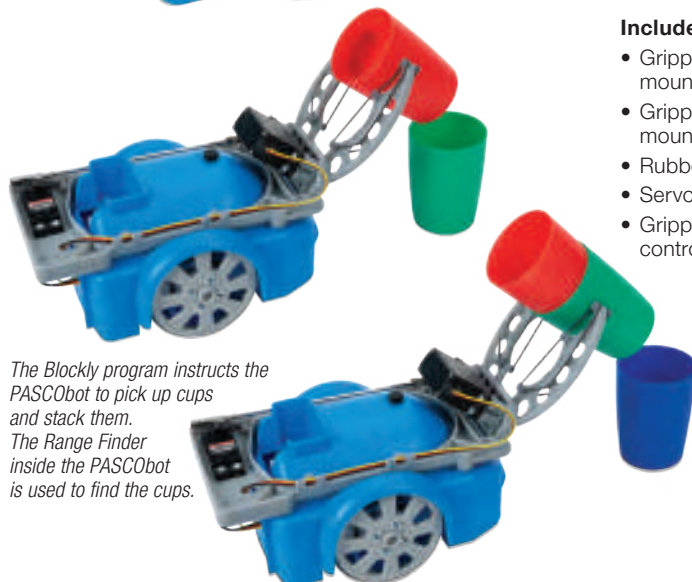
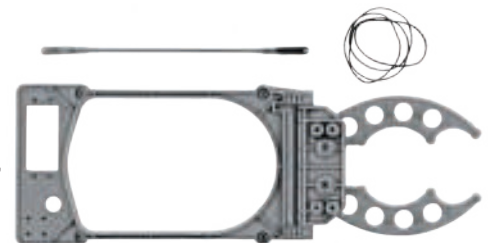
The Gripper jaws are designed to grasp small and large objects.



In Blockly, the strength of the Gripper's grasp is programmed in response to the amount of current the servo motor is drawing. The higher the current, the stronger the grip.

Includes:

- Gripper arms and mounting brace assembly
- Gripper accessory mounting hardware
- Rubber bands
- Servo extension cable, 12"
- Gripper raise and lower control rod with clips



The Blockly program instructs the PASCObot to pick up cups and stack them. The Range Finder inside the PASCObot is used to find the cups.

Order Information

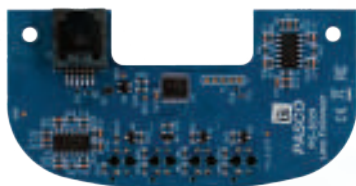
PASCObot Gripper Accessory	PS-3325
Required:	
PASCObot	PS-2994
Servo Motor (2)	SE-2975
PASCO Capstone Software	pp. 8-11
OR	
SPARKvue Software	pp. 12-13
Recommended:	
PASCObot Range Finder Module	PS-3321
Colored Plastic Cup Set (set of 5)	SE-2952

PASCObot Line Follower

PASCObot Line Follower Module

PS-3320

- Program the PASCObot to follow a custom line path!

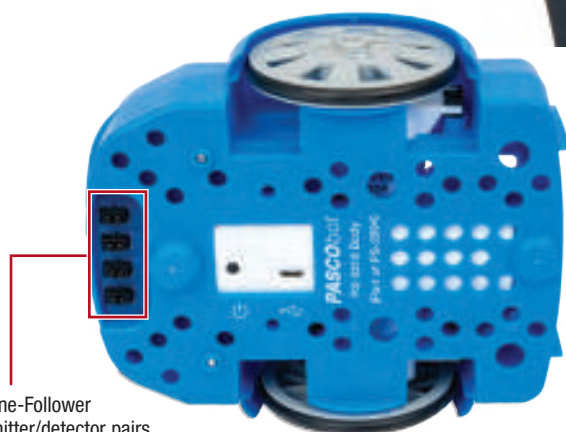


When fitted with the Line Follower Module, the PASCObot can detect, follow, and respond to line paths based on code. To create a path, students use either the black or white tape included with the PASCObot Sense & Control Kit (ST-7840). They can then program the bot's navigation through the path, upload their code to the bot, and put their coding skills to the test!

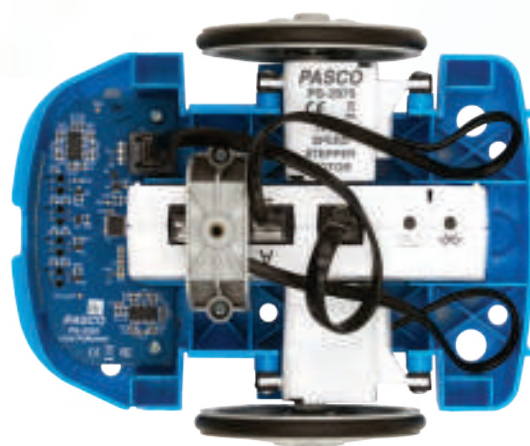
Loaded code is run autonomously, allowing guiding decisions to be made onboard the PASCObot for more instantaneous responses. As the PASCObot autonomously executes the uploaded code, students can monitor data from the bot's onboard sensors in real time by connecting their computer via Bluetooth.



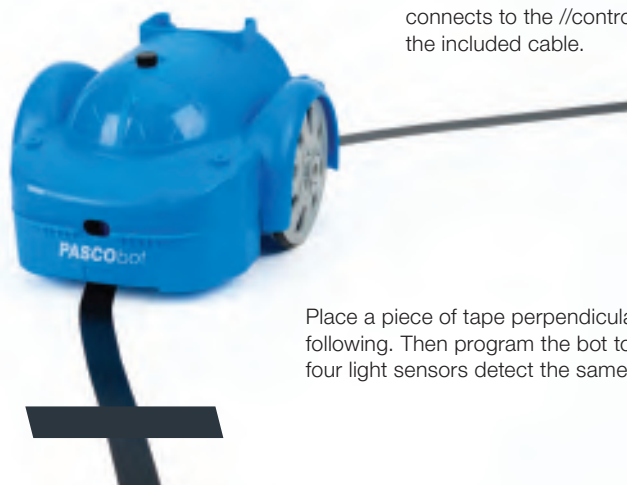
The tape is very flexible and leaves no residue after removing it from a table or floor.



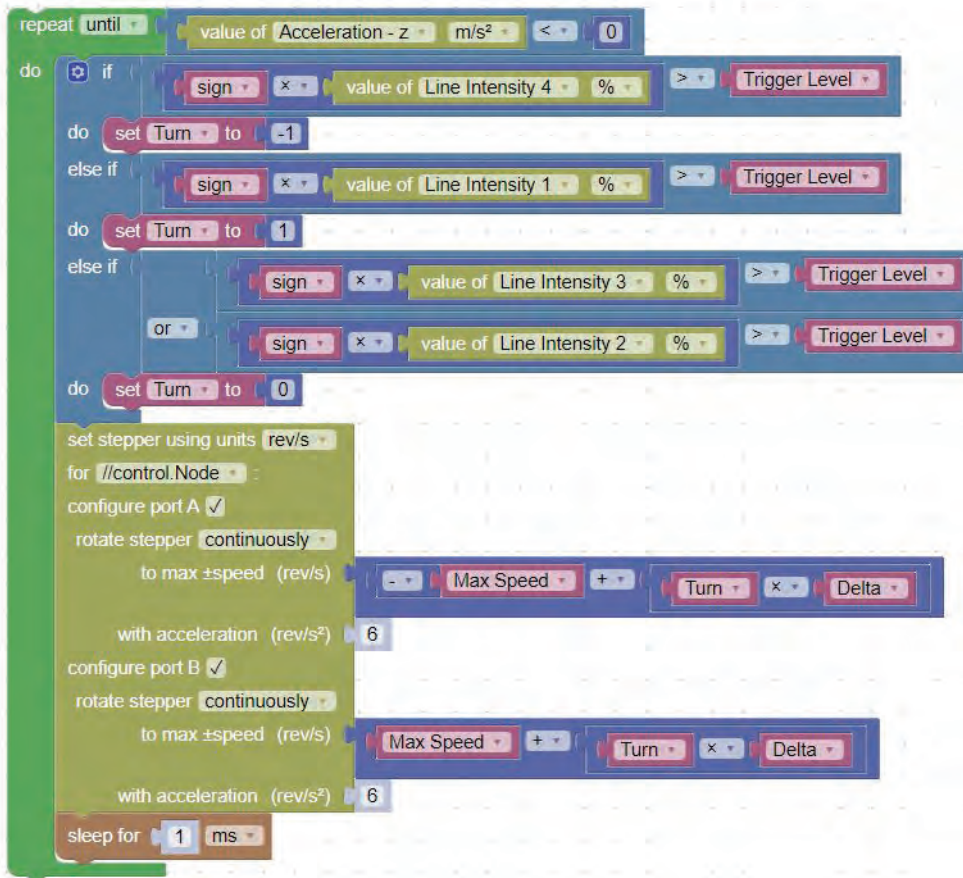
The four Line-Follower infrared emitter/detector pairs shine through a hole in the bottom of the PASCObot.



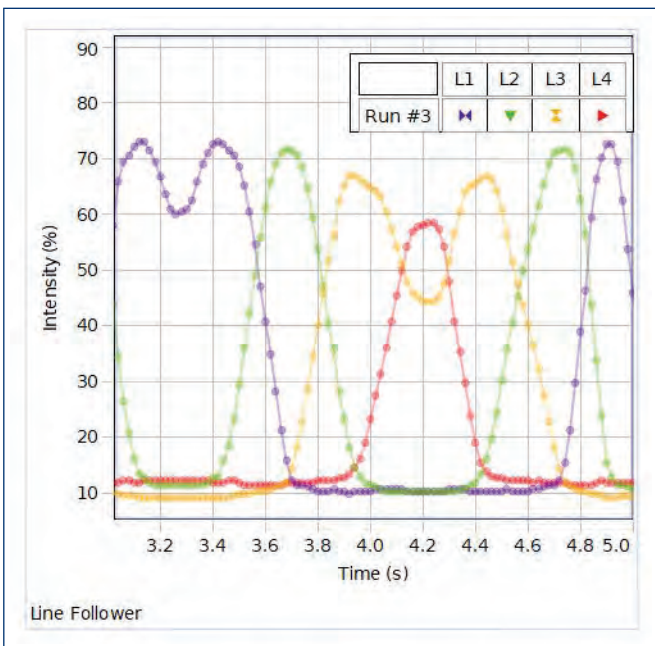
This circuit board mechanically fits into the PASCObot and connects to the //control.Node's Digital Sensor Port using the included cable.



Place a piece of tape perpendicular across the line the bot is following. Then program the bot to stop and reverse when all four light sensors detect the same value.



The PASCObot readily scales to student learning levels. Students can write their own line-following code, or they can download prepared line-following blocks from the PASCO Code Library (included in SPARKvue and PASCO Capstone).

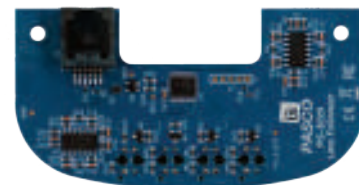


Note that the Line Follower cannot be used simultaneously with the Range Finder since both occupy the same slot in the PASCObot.

By studying the reflected light levels coming from the four emitters, students can design code that recognizes when the PASCObot is over the line and which direction the PASCObot needs to go to return to the line.

Includes:

- PASCObot Line Follower Module
- Cable to connect the module to //control.Node
- 4-40 x 7/16" screw for mounting the module to the PASCObot body (2)



Order Information

PASCObot Line Follower Module	PS-3320
Required:	
PASCObot	PS-2994
PASCObot Line Follower Tape	
Black & White Tape Rolls (1 each)	SE-2953
PASCO Capstone Software	pp. 8-11
OR	
SPARKvue Software	pp. 12-13

Meter Stick Physics

Aluminum Meter Sticks (6 Pack)

ME-7032



These aluminum meter sticks are rigid and straight. Because they are hollow, the aluminum meter stick has about the same mass as a wooden meter stick. Both sides are marked in centimeters.

Specifications:

Length: 1 m
Resolution: 1 mm
Mass (per stick): 150 g
Width: 28 mm
Thickness: 7 mm
Inner Width: 26.4 mm
Inner Thickness: 5.4 mm
Material: Aluminum



Includes:

- Aluminum Meter Sticks (6)

Order Information

Aluminum Meter Sticks (6 Pack) ME-7032

Half-Meter Stick

ME-7044



This so-called “Half-Meter” Stick is actually 60 cm long. These aluminum meter sticks are rigid and straight. Because they are hollow, the aluminum meter stick has about the same mass as a wooden meter stick. Both sides are marked in centimeters.

The length of this stick makes it particularly useful for rotation and torque experiments in which the stick is rotated on a Pivot (ME-7034) or Rotary Motion Sensor using the meter stick clamp that is included in the Meter Stick Torque Mass Hanger Set (ME-7035).

Specifications:

Length: 60 cm
Resolution: 1 mm
Mass: 90 g
Width: 28 mm
Thickness: 7 mm
Inner Width: 26.4 mm
Inner Thickness: 5.4 mm
Material: Aluminum

Includes:

- 60-cm long aluminum meter stick

Order Information

Half-Meter Stick ME-7044

Ball Ramp

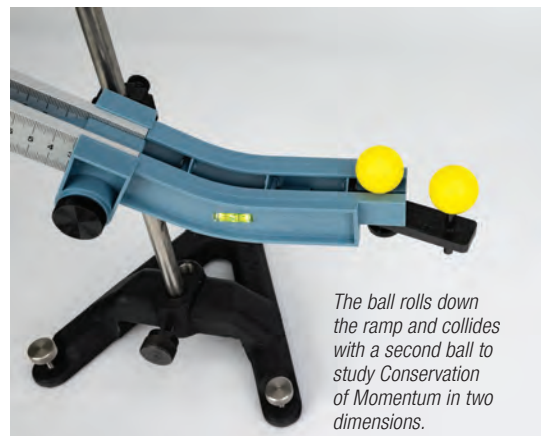
ME-7075

NEW

The Ball Ramp can be used as a projectile launcher and as an inclined plane. Two meter sticks form rails for a ball to roll on. The curved end of the Ball Ramp allows the ball to roll off the end of ramp horizontally. There is a level in the curved end so you can tell when the end is horizontal.

The angle of the Ball Ramp can be adjusted by clamping one end to a rod stand. Photogate Rod Clamps hold the meter sticks in place and provide a rod clamp as well as a place to attach a photogate. The Photogate Rod Clamp is compatible with Smart Gates and Photogate Heads. A photogate can also be mounted on the curved end of the Ball Ramp to record the speed right before the ball leaves the ramp.

To study Conservation of Momentum in two dimensions, the 2-D Collision Accessory can be mounted on the end of the curved end of the Ball Ramp, allowing the ball rolling down the ramp to collide with a second ball.



The ball rolls down the ramp and collides with a second ball to study Conservation of Momentum in two dimensions.

Perform These Experiments:

- ▶ Projectile Motion
- ▶ Uniform Acceleration Down an Inclined Plane
- ▶ Conservation of Energy of a Ball Rolling Down an Incline
- ▶ Conservation of Momentum in Two Dimensions

Specifications:

Length of Ramp: 1 m
Distance Between Meter Stick Rails: 1 cm
Diameter of Ball: 2.54 cm
Designed for Meter Stick Cross-Section
Dimensions: 7 mm x 28 mm

Includes:

- Ball Ramp Components: ME-7073
- Aluminum Meter Stick (2)
- Wireless Smart Gate: PS-3225
- Photogate Head: ME-9498A



Order Information

Ball Ramp ME-7075

Meter Stick Mechanics Set

ME-7076 (without Sensors ME-7081)

Perform experiments in dynamics, projectile motion, and rotation with this meter-stick-based set. This set combines the capabilities of three sets:

- Ball Ramp
- Meter Stick Rotation Set
- Meter Stick Torque Set

Includes:

- Meter Stick (2)
- Half-Meter Stick: ME-7044
- Pivot: ME-7034
- Meter Stick Torque Mass Hanger Set: ME-7035
- Ball Ramp Components: ME-7073
- Meter Stick Rotation Components: ME-7072
- Wireless Force Acceleration Sensor: PS-3202
- Wireless Smart Gate: PS-3225
- Photogate Head: ME-9498A
- Small A-Base with Leveling Feet: ME-8989
- Stainless Steel Rod, 45 cm: ME-8736
- Mass and Hanger Set: ME-8979
- Super Pulley with Mounting Rod: ME-9499
- Multi-Clamp: ME-9507



Perform These Experiments:

- ▶ Uniform Acceleration Down an Inclined Plane
- ▶ Projectile Motion Using a Ball Ramp
- ▶ Conservation of Energy of a Ball Rolling Down an Incline
- ▶ Conservation of Momentum in Two Dimensions
- ▶ Centripetal Force
- ▶ Rotational Inertia of a Point Mass
- ▶ Rotational Inertia of a Thin Rod
- ▶ Meter Stick Torque
- ▶ Analyzing a Static Beam
- ▶ Physical Pendulum
- ▶ Exploring a Rotating System
- ▶ Exploring Torque
- ▶ Falling Beam
- ▶ Static Equilibrium

Order Information

Meter Stick Mechanics SetME-7076
Meter Stick Mechanics Set without Sensors.....ME-7081

Ball Ramp Components

ME-7073

Add two meter sticks to these components to make a Ball Ramp (ME-7075).

Two meter sticks form rails for a ball to roll on. The curved end of the Ball Ramp allows the ball to roll off the end of ramp horizontally for projectile motion studies. There is a level in the curved end so you can tell when the end is horizontal.

The angle of the Ball Ramp can adjusted by clamping one end to a rod stand. Photogate Rod Clamps hold the meter sticks in place and provide a rod clamp as well as a place to attach a photogate. The Photogate Rod Clamp is compatible with Smart Gates and Photogate Heads. A photogate can also be mounted on the curved end of the Ball Ramp to record the speed right before the ball leaves the ramp. To study Conservation of Momentum in two dimensions, the 2-D Collision Accessory can be mounted on the end of the curved end of the Ball Ramp, allowing the ball rolling down the ramp to collide with a second ball.



Includes:

- Photogate Rod Clamp (2)
- Curved End with Bubble Level and Rod Clamp
- Steel Ball (1-inch diameter) (2)
- Plastic Ball (1-inch diameter) (2)
- 2-Dimensional Collision Accessory
- Ball Ramp End Stop



Order Information

Ball Ramp Components.....ME-7073

Ball Ramp End Stop

ME-7077



The ball ramp end stop catches the ball before it rolls off the end of the ramp. This end stop is made of foam and slides onto the Ball Ramp (ME-7075). There is a small hole on one face to indicate which way the end stop should be oriented. The face with the small hole should be facing up the incline so the ball goes in without bouncing back. It catches the ball so you don't have to chase it across the classroom.

Includes:

- Foam End Stop



Order Information

Ball Ramp End StopME-7077

Meter Stick Physics

Meter Stick Torque Set

ME-7033

Create an improved version of the meter stick balance by mounting the Pivot on a rod stand and using an aluminum meter stick. The Meter Stick Clamp has a built-in bubble level to indicate when the meter stick is level.

The Meter Stick Clamp fits onto either the provided dual-ball bearing Pivot or a Rotary Motion Sensor. It has two mounting points: One is centered on the center of the meter stick for rotation and pendulum experiments and the other is offset so the center of mass of the meter stick is below the pivot point for stability in meter stick torque experiments.

The mass hangers have a mass of 10 grams each, which makes it easy to add to the hanging mass. The Mass Hangers have a degree scale so the angle of the applied force can be read. The Mass Hangers can be used in two ways:

- As a mass hanger in a meter stick torque experiment with the masses hanging from it
- Upside-down, as an anchor point for a suspension string at any angle in a statics experiment.

Features:

- ▶ Dual ball bearings in Pivot
- ▶ Mount at any height on any rod stand
- ▶ Mass hangers (10 g) have built-in angle indicators
- ▶ Built-in bubble level on Pivot meter stick clamp

Specifications:

Aluminum Meter Stick Dimensions:

6.95 mm x 28.0 mm x 1.0 m

Aluminum Meter Stick: Approximate mass 150 g

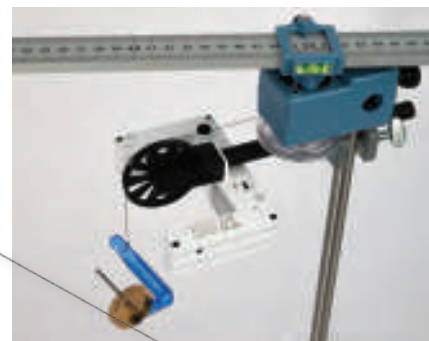
Pivot Slotted Shaft: 1/4-inch (6.35 mm) diameter, 16 mm long out both sides

Mass of Hangers: 10 g

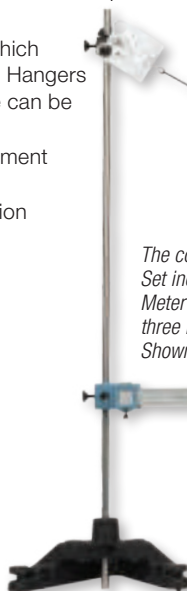


Perform These Experiments:

- ▶ Meter Stick Torque
- ▶ Statics – Suspended Boom
- ▶ Physical Pendulum



The complete Meter Stick Torque Set includes the Pivot, Aluminum Meter Stick, Meter Stick Clamp, and three Mass Hangers. Shown in use with Wireless Force Sensor.



Includes:

- Pivot: ME-7034
- Meter Stick Torque Mass Hanger Set: ME-7035
- Aluminum Meter Stick

Order Information

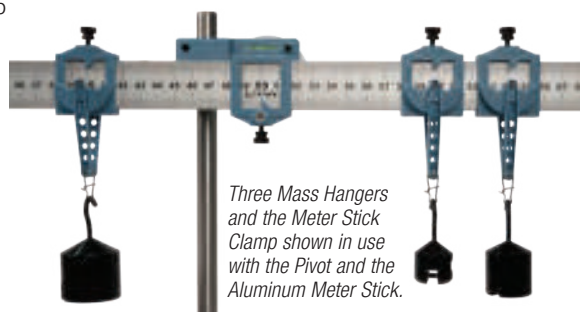
Meter Stick Torque Set..... ME-7033

Required:

Rod Stand..... p. 204

Meter Stick Torque Mass Hanger Set

ME-7035



Three Mass Hangers and the Meter Stick Clamp shown in use with the Pivot and the Aluminum Meter Stick.

Replacement set of three Mass Hangers and one Meter Stick Clamp for doing meter stick torque experiments.

The meter stick clamp fits onto either a Pivot (ME-7034) or a Rotary Motion Sensor.

Includes:

- Meter Stick Clamp
- Mass Hangers (3)



Order Information

Meter Stick Torque Mass Hanger Set ME-7035

Required:

Aluminum Meter Sticks (6 pack) ME-7032 p. 208

Pivot

ME-7034

The Pivot is a general purpose rotation device that allows you to mount it on a rod stand to perform rotation experiments in the horizontal or vertical planes.

Perform These Experiments:

- ▶ Meter Stick Torque
- ▶ Rotational Inertia
- ▶ Physical Pendulum
- ▶ Centripetal Acceleration

Includes:

- Pivot
- 3-step Pulley



This Pivot can be used as a fulcrum for meter stick torque experiments or as a rotational platform for rotational inertia experiments.

Order Information

Pivot..... ME-7034

Meter Stick Rotation Set

NEW

ME-7074 (without Sensors ME-7078)

In the Meter Stick Rotation Set, a Half-Meter Stick rotates about any point desired. The Wireless Force Sensor can be attached to the rotating meter stick to directly measure the centripetal force on a mass attached to the Force Sensor with a string.

The Meter Stick Rotation Set includes two mass holders that can slide freely on the meter stick or be fixed in place. The rotational inertia of the apparatus can be determined by accelerating the apparatus by a mass hanging over a pulley with a photogate.

Specifications:

Mass of Mass Holder: 20 g

Maximum Mass that fits in the Mass Holder: 100 g (two 50-g masses)

Masses included: Six 20-g masses and six 50-g masses

Length of Half-Meter Stick: 60 cm



Perform These Experiments:

- ▶ Centripetal Force – Vary mass, radius, and angular speed
- ▶ Rotational Inertia of a Thin Rod
- ▶ Rotational Inertia of a Point Mass as a Function of Radius

Includes:

- Meter Stick Rotation Components: ME-7072
- Half-Meter Stick: ME-7044
- Pivot: ME-7034
- Wireless Force Acceleration Sensor: PS-3202
- Wireless Smart Gate: PS-3225
- Replacement Mass Set, 50 g: ME-8984
- Replacement Mass Set, 20 g: ME-8983
- Small A-Base with Leveling Feet: ME-8989
- Stainless Steel Rod, 45 cm: ME-8736
- Super Pulley with Mounting Rod: ME-9499
- Multi-Clamp: ME-9507

Order Information

Meter Stick Rotation Set ME-7074
Meter Stick Rotation Set without Sensors..... ME-7078

Meter Stick Rotation Components

NEW

ME-7072



These are the basic components of the Meter Stick Rotation Set (ME-7074). To use these components, you need a Half-Meter Stick, a Pivot, and a rod stand. The Mass Holders are designed to use the cylindrical masses from Mass and Hanger Set (ME-8979).

In the Meter Stick Rotation Set (ME-7074), a Half-Meter Stick rotates about any point desired. The Wireless Force Sensor can be attached to the rotating meter stick to directly measure the centripetal force on a mass attached to the Force Sensor with a string.

The Meter Stick Rotation Components include two mass holders that can slide freely on the meter stick or be fixed in place. The rotational inertia of the apparatus can be determined by accelerating the apparatus by a mass hanging over a pulley with a photogate.

Includes:

- Meter Stick Holder with Force Sensor Post
- Mass Holder (2)

Order Information

Meter Stick Rotation Components..... ME-7072

Meter Stick Optics Complete System

OS-7052



PASCO's Meter Stick Optics Complete System includes all of the components needed to explore essential optics topics like image magnification, lens focal length, real and virtual images, combination of lenses, and so much more! This simple but robust system is designed to fit directly onto the included PASCO Aluminum Meter Stick, making measurements of object distance and image distance easy and straightforward for students.

The rechargeable LED light source provides long-lasting battery life and is bright enough to form clear images in a fully-lit classroom! The component holders and the viewing screen mount firmly on the meter stick, but can also be easily moved along the length of the meter stick. This makes the formation of real images easy to find and measure.

The high-quality lenses are clearly labeled and held firmly inside component holders. Using the built-in holding tabs, the lenses can be quickly exchanged in the component holders. Each lens comes with built-in standoffs to protect the lens surface from scratching and scuffing when placed flat on a tabletop.

All the components, with the exception of the meter stick, fit in the included storage box. This cost-effective set offers an all-in-one alternative to traditional optics benches and meets all the needs of introductory optics lessons.

Includes:

- Aluminum Meter Stick
- Meter Stick Optics Light Source: OS-7054
- Meter Stick Optics Component Holder: OS-7055 (2)
- Meter Stick Optics Viewing Screen: OS-7056
- Lens, -150 mm
- Lens, +100 mm
- Lens, +200 mm
- Storage Box

Order Information

Meter Stick Optics Complete System OS-7052

DYNAMICS SYSTEMS

PASCO introduced the first dynamics system in 1992 and we have been refining it ever since. It all started with sturdy aluminum carts. Soon, we added an aluminum dynamics track to align collisions. Next came the plastic systems which brought new possibilities, as they were lightweight, durable, and allowed for innovations such as curved tracks. Then in 2016, PASCO introduced the Smart Cart, the first fully instrumented dynamics cart. Now, these three types of carts are compatible with both types of tracks, and there are many accessories to complete your lab.

Metal Tracks

- Available in 1.2 m or 2.2 m lengths
- Straight and rigid
- Supports induced magnetic drag because it's conductive
- Feet can be placed at any position
- High-contrast scale



NOTE: All carts and tracks are interchangeable. Go to the QR code (URL) above for help deciding what dynamics system is right for you.

Smart Carts

- Completely instrumented with motion and force sensors
- Multiple Smart accessories
- Measurement synchronization between carts



Scan to learn more!



Plastic Carts

- Most affordable
- Four string tie positions
- Three-position plunger

Plastic Tracks

- Add tracks to extend the length
- Lightweight
- Supports curved track for hills
- Built-in feet
- Storage: 1-meter track disassembles into two 50-cm parts
- More affordable



Metal Carts

- More inertia
- Sturdy body
- Separate plunger and collision carts



INDUSTRY LEADER

PASCO's Dynamics Cart & Track Systems set the standard in educational quality, versatility, and ease of use. Today, they are the cornerstone of countless physics labs and demonstrations, ranging from introductory investigations of kinematics and dynamics to advanced studies of optics and diffraction. We make it easy to find a dynamics system that's right for both your course and your budget.

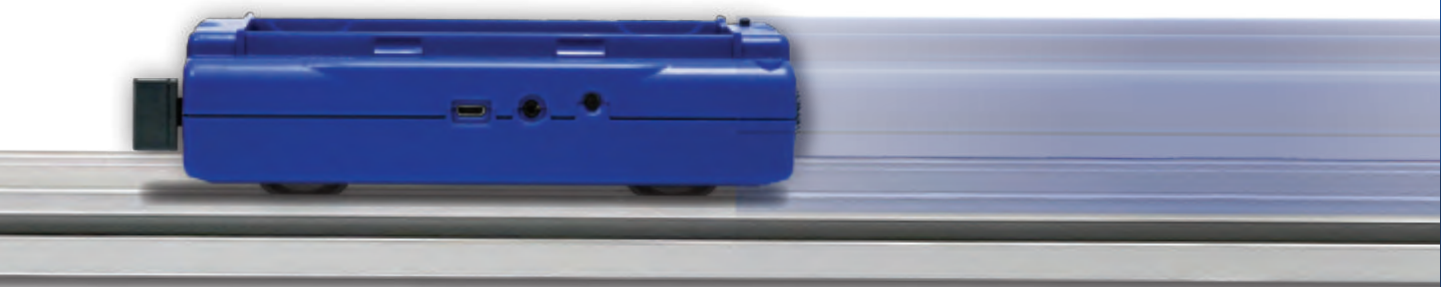


Basic Set Options	Plastic Track 1 m	Metal Track 1.2 m	Metal Track 2.2 m
Plastic Carts	ME-5701A	ME-5702A	ME-5703A
Metal Carts	N/A	ME-5705A	ME-5706A
Smart Carts	ME-5707B	ME-5708B	ME-5709B

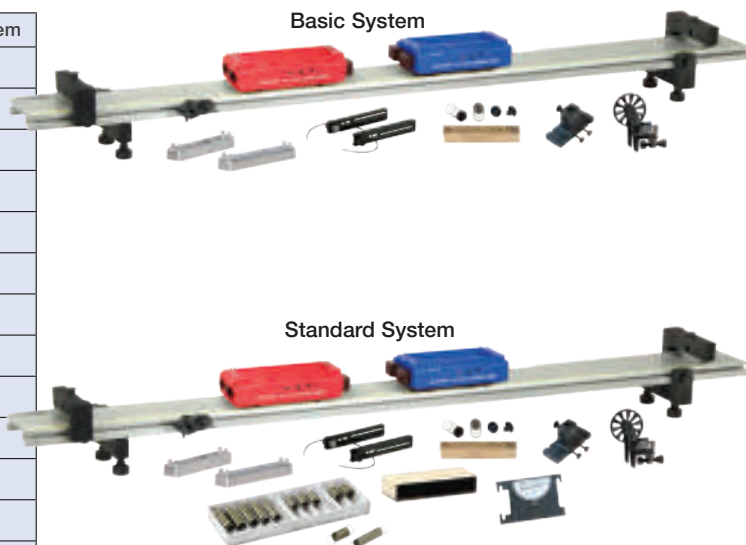
Standard Set Options	Plastic Track 1 m	Metal Track 1.2 m	Metal Track 2.2 m
Plastic Carts	ME-5711A	ME-5712A	ME-5713A
Metal Carts	N/A	ME-5715A	ME-5716A
Smart Carts	ME-5717B	ME-5718B	ME-5719B

PASCO's Smart Cart and 1.2 m Aluminum Track is the Dynamics System of Choice.

Featuring the amazing Smart Cart—a complete physics lab on wheels—and our high precision, durable aluminum tracks (available in 1.2 and 2.2 m options), this dynamics system will not disappoint.



	Basic System	Standard System
Track	✓	✓
2 Carts	✓	✓
2 Endstops	✓	✓
2 Leveling Feet*	✓	✓
2 Mass Bars**	✓	✓
Rod Clamp	✓	✓
Elastic Bumper	✓	✓
Clamp-on Super Pulley	✓	✓
Bumper Accessory Set***	✓	✓
Smart Cart Rod Stand Adapter***	✓	✓
Friction Block		✓
Angle Indicator		✓
Dynamics Track Spring Set		✓



*Leveling feet are not included with plastic track, since they are already built into the track.

**Metal carts include two additional Mass Bars.

***Smart Cart Rod Stand Adapter and Bumper Accessory Set are only included with Smart Cart Systems.

AMAZING SMART CART

The patented Smart Cart is the ultimate tool for studying kinematics, dynamics, Newton's Laws, and more. It is based on a durable ABS body with nearly frictionless wheels, just like our high quality PAScars. Now, we've added built-in sensors that measure force, position, velocity, and acceleration. The versatile Smart Cart can collect measurements on or off a track and transmit the data wirelessly over Bluetooth. In essence, it is a wireless dynamics cart that combines all the necessary sensors, without requiring any additional hardware.

- Built-in force sensor (± 100 N)
- Built-in 3-D acceleration sensor (± 16 g)
- Optical encoder measures motion
- Data is transmitted wirelessly
- No interface required
- Rechargeable lithium-polymer battery

Mounting
threads for
accessories

3-Axis Acceleration
Gyro Sensor

Mass Tray

U.S. Patent Number
10,481,173

Force Sensor

- Hook
- Magnetic Bumper
- Rubber Bumper

Encoder wheel
for linear position,
velocity, and
acceleration

Power
Button

Accessory Port

- Smart Fan
- Ballistic Cart Accessory
- Vector Display
- Smart Cart Motor

USB Charging Port



[Learn More](#)

Smart Cart Red & Blue - ME-1240/ME-1241

Every Smart Cart includes a magnetic bumper and
Velcro® tabs for elastic and inelastic collisions!

Plunger
release
3-position
plunger

Velcro® tabs
for inelastic collisions

Imagine the Possibilities

Here are just a handful of the many investigations you can conduct with wireless Smart Carts. You can find full teaching and learning support such as standards-aligned labs and answer keys on PASCO Portal® for science educators.

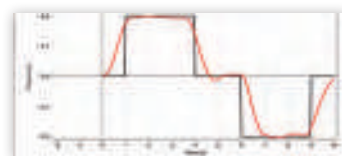
Directly measure the tension in the string when connected to the Smart Cart

While the cart is stationary, the tension is equal to the hanging weight. When the cart accelerates, the tension is less than the hanging weight.



Match Position and Velocity vs. Time

Graph it with FREE MatchGraph! Software.



Measure oscillations of a cart & spring

Measure the position, velocity, and acceleration of the cart, and the force of the spring.



Go trackless!

Smart Cart can be used with or without a dynamics track. Measure velocity as the cart travels across the floor or table without a track.



Use two Smart Carts for collisions

Each cart measures its own velocity and force. Will students correctly predict the forces recorded by each cart for these parameters?



Measure cart velocity on a curved track

Measure velocity where Motion Sensors cannot work because there is no straight line of sight.



DYNAMICS SYSTEMS

BUT WAIT... THERE'S MORE

The Smartest choice for your physics lab

Smart Cart is the ultimate tool for studying kinematics, dynamics, Newton's laws, and more.



**Smart Fan
Accessory &
Rotation Base**

PASCO's Smart Cart And Accessories

With PASCO Smart Carts & innovative accessories you truly have a physics lab on wheels



**Smart Cart
Motor**

**Ballistic Cart
Accessory**

Smart Cart Vector Display

THE ORIGINAL
Patent No. 10481173
Patent No. 10482789



Ball Catcher

Trigger Dropper

Smart Carts truly are a physics lab on wheels

Now you can own the most advanced physics cart ever created, all without the restrictions of cables.



Smart Cart Accessories

PASCO continues to add to its line of Smart Cart accessories to open up new demonstration opportunities and extend the physics learning in your lab. Smart accessories and PASCO software with Blockly enable coding or sense & control.

Smart Fan Accessory

ME-1242

What makes this fan so smart? If you use this fan on a regular cart, you can turn it on and select one of three speeds by pushing the button on the side. But plugging it into a Smart Cart gives this Smart Fan Accessory added capabilities:

- Hands-off Operation
- Adjust the Thrust
- Reverse the Spin of the Fan
- Set Start and Stop Conditions
- Sense and Control



Smart Cart Fan Kit

ME-1254

NEW



What makes this fan so smart? It includes a rotating platform that can be used to demonstrate the vector nature of force. Raised markings on the base indicate the angle of the fan with respect to the path of the cart. The base can rotate in 15 degree intervals, snapping between each position, making it easy to set the angle of the fan.

An included sail attaches to the cart where the fan can blow into the sail, demonstrating Newton's Third Law by remaining stationary. When the concave side of the sail faces the fan, the air rebounds off the sail and moves the cart.

Fan Sail

ME-1248

This sail fits into a Smart Cart or Super Fan Cart (ME-6977) so the fan can blow into the sail, demonstrating Newton's Third Law by remaining stationary. When the concave side of the sail faces the fan, the air rebounds off the sail and moves the cart.



The fan blows into the sail, demonstrating Newton's Third Law by remaining stationary.

Fan Rotation Base

ME-1251

The Fan Rotation Base features a rotating platform that can be used to demonstrate the vector nature of force. It attaches to any PASCO dynamics cart and can mount to the Smart Fan Accessory or legacy Fan Accessory. Raised markings on the base indicate the angle of the fan with respect to the path of the cart. The base can rotate in 15 degree intervals, snapping between each position, making it easy to set the angle of the fan.



Smart Cart Rod Stand Adapter

ME-1244

This accessory allows the Smart Cart to be suspended from a rod stand. Use the Smart Cart's force sensor to measure the force of an oscillating spring and mass. The Smart Cart can be mounted directly to a vertical rod or to a horizontal cross-rod.



DYNAMICS SYSTEMS AND ACCESSORIES

Smart Ballistic Cart Accessory

ME-1245

The Smart Ballistic Cart Accessory mounts to any PASCO dynamics cart for a classic demonstration on the independence of X and Y motion. A projectile fired from the accessory while a cart is in motion will be caught farther down the track. When mounted to a PASCO aluminum cart, or PAScar, the projectile is launched using a push button timer delay. When connected to a PASCO Smart Cart, the Smart Ballistic Accessory can launch the projectile based on measurements made by the Smart Cart in either SPARKvue or PASCO Capstone software.

**Smart Cart Friction Brake**

ME-1253

NEW

The Smart Cart Friction Brake is designed to bring a moving Smart Cart to a stop at any position on a dynamics track. For example, when using a Curved PASTrack setup, you can apply the friction force on the flat section of track instead of the inclined section. The brake uses the friction between a felt strip on the cart and a rounded thumbscrew on the track to reduce the cart's velocity.

**Ball Catcher**

ME-1252

The Ball Catcher mounts on a dynamics cart or a rotating meter stick to catch a ball shot from a projectile launcher. It has adjustable sides to accommodate 1-inch plastic balls from the Projectile Launcher (ME-6800) or 5/8-inch steel balls from the Mini Launcher (ME-6825B).

The Ball Catcher fits onto any PASCO dynamics cart or Smart Cart and can also slide onto a PASCO Half-Meter Stick (ME-7044) and be fixed in place with a screw. When the half-meter stick is equipped with the meter stick clamp from the Meter Stick Torque Mass Hanger Set (ME-7035), the half-meter stick can be mounted on a rotary motion sensor to rotate in the horizontal plane when a ball is shot into the Ball Catcher.

The half-meter stick on a rotary motion sensor can also be oriented in the vertical plane to form a ballistic pendulum.

The Ball Catcher also fits on the end of a meter stick to do conservation of angular momentum experiments and to create a ballistic pendulum



A Projectile Launcher shoots a ball into the Smart Cart to perform a conservation of momentum experiment.



In the trigger mode, the plunger on the Blue Smart Cart is released, causing the red and blue carts to explode apart.

Smart Cart Trigger Dropper

ME-1249

This dual-purpose device can trigger the Smart Cart plunger or drop a ball from the side of a Smart Cart.

Trigger the Smart Cart plunger remotely for conservation of momentum experiments. The Trigger Dropper mounts in the bed of the Smart Cart, parallel to the cart, and is connected to the Smart Cart's accessory port. The plunger is released when the Trigger Dropper is activated either by pushing the button on the Trigger Dropper or remotely through Capstone or SPARKvue software.

Drop a ball from a moving Smart Cart to demonstrate projectile motion. The Trigger Dropper mounts in the bed of the Smart Cart, perpendicular to the cart. The ball is dropped when the Trigger Dropper is activated in the software. It can be activated after a specified time or when the cart reaches a specified position. When the ball hits the floor, where is the cart relative to the ball?

The Trigger Dropper can also be programmed in Blockly.



DYNAMICS SYSTEMS AND ACCESSORIES



Smart Cart Motor

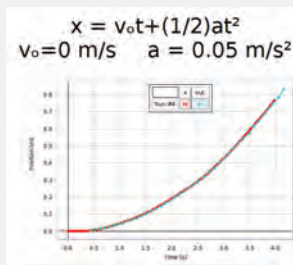
ME-1247

The Smart Cart Motor is a motor-driven wheel that attaches to the Smart Cart to make it go at a constant velocity, forwards or backwards. In PASCO Capstone or SPARKvue, you can control the motor remotely through its wired connection to the Smart Cart by setting the power on a scale of -100 to +100%.

The Smart Cart Motor can be programmed in Blockly in PASCO Capstone or SPARKvue to execute movements based on sensor measurements. For instance, the Motor can be programmed to decrease in velocity as the position of the Smart Cart increases. You can program the Smart Cart to follow equations of motion and graph the real-time motion on a plot of the theoretical equation of motion.



Program with Blockly in Capstone or SPARKvue to make the Smart Cart with Motor follow an equation of motion.



You can program the Smart Cart to follow equations of motion and graph the real-time motion on a plot of the theoretical equation of motion.



Smart Cart Vector Display

ME-1246

The Smart Cart Vector Display adds visual vectors to your Smart Cart for Force, Acceleration, or Velocity. Connect it to the Smart Cart's accessory port to visualize vectors in real time! The arrows light up proportional to the sensor reading and indicate both magnitude and positive or negative direction.

Features:

- ▶ Choose from Force, Acceleration, or Velocity vectors and watch them in real time.
- ▶ Students can visualize constant acceleration as a cart rolls up and then down an incline.
- ▶ Great for the student lab station or for a physics lecture demonstration!
- ▶ Selectable ranges



Smart Cart Demonstration Kits

ME-1272A/ME-1273A

The Red Smart Cart Demonstration Kit comes with a Red Smart Cart and all the accessories you need to perform amazing physics demonstrations in kinematics and dynamics.

Features:

- Red or Blue Smart Cart
- Smart Fan Accessory with Rotation Base and Sail
- Smart Cart Motor
- Smart Cart Trigger Dropper
- Smart Ballistic Cart Accessory
- Smart Cart Vector Display
- Grattells Case
- Demonstration Manual

Demonstrate:

- Differences between Velocity and Acceleration
- Independence of Horizontal and Vertical Projectile Motion
- Newton's First Law
- Newton's Second Law
- Newton's Third Law
- Impulse and Force
- Force and Acceleration in Collisions
- Centripetal Acceleration
- Compare Velocity, Acceleration, and Force in Simple Harmonic Motion
- Buoyant Force and Archimedes' Principle
- Fan Force Components
- Equations of Motion
- Independence of Kinetic Friction on Velocity
- Race between a Fan Cart and a Constant Velocity Cart
- Ball Dropped from a Moving Cart
- Conservation of Momentum in Explosions
- Conservation of Center of Mass in Explosions



Smart Fan Accessory
Mounts directly to all PASCO carts to provide a constant force.



Smart Cart Vector Display
The Smart Cart Vector Display adds visual vectors to your Smart Cart for force, acceleration, or velocity.



Smart Ballistic Cart Accessory
Mounts to any PASCO dynamics cart for a classic demonstration on the independence of X and Y motion.



Smart Cart Trigger Dropper
This dual-purpose device can trigger the Smart Cart plunger or drop a ball from the side of a Smart Cart.



Smart Cart Motor
Add power to your Smart Cart and control its motion through Blockly coding.



DYNAMICS SYSTEMS AND ACCESSORIES

PAStack

The PAStack's two-piece construction makes storage easy. Snap-on connector clip holds sections straight and rigid. Use the second clip (included) to connect multiple tracks! The track ends are designed to accept the Motion Sensor and Clamp-on Pulley, and the side T-slots accept Dynamic Track accessories, such as photogate brackets and end stops. Track includes six built-in leveling feet.

- Track just snaps together
- Built-in scale
- T-slot: accepts Dynamics Track accessories
- Six leveling feet
- Motion Sensor or clamp-on pulley fits both ends



PAStack

ME-6960

Connect two 0.5-m length tracks and use with dynamics carts to study motion.



Curved PAStack

ME-6841

Expand your PAStack System with this curved track set. Create hills, valleys and inclines.



PAStack Inclined Plane

ME-6967

The PAStack Inclined Plane includes the Inclined Plane Accessory (ME-6965) and the PAStack (ME-6960)





Track Rod Clamp

ME-9836

Fastens to the T-Slot of a Dynamics track and accepts a 1/2 inch rod.



Dynamics Track Feet

ME-8972

A pair of adjustable feet for the classic aluminum tracks included in PASCO Dynamics Systems.



Dynamics Cart Magnetic Damping

ME-6828

Damps the motion of a Dynamics Cart, Smart Cart, or a PAScar on the aluminum Dynamics Track.



Super Fan Cart

ME-6977

Super Fan Cart provides a constant force and is rechargeable and programmable.

Variable Speed Motorized Cart

ME-9781

Cart has adjustable speed and climbs up a 30 degree slope.



Constant Velocity Car

SE-8028

For constant velocity demonstrations and labs. It will roll at a constant velocity. When it reaches a wall, it flips over and changes direction.



Mechanical Oscillator/Driver

ME-8750

Delivers repeatable, low-frequency, high-force sinusoidal motion for harmonic motion experiments.



Spring Cart Launcher

ME-6843

The Spring Cart Launcher provides an economical way to launch carts in a repeatable fashion



Friction Block

ME-9807

The wooden Friction Block has felt on two sides, so the frictional coefficients for felt or wood can be measured.



Discover Friction Accessory

ME-8574

Four plastic trays with unique surfaces (cork, felt, and 2 plastic) to use with dynamics carts and sensors.



Car Sail

ME-9595

The Car Sail allows students to study the effects of air resistance on PASCO carts.



Force Sensor Track Bracket

ME-6622

For use in collision studies using PASCO carts and tracks. Mounts force sensors and includes accessories for investigating elastic and inelastic collisions.

DYNAMICS SYSTEMS AND ACCESSORIES

**Bumper Accessory Set**

ME-9884

This set of bumpers can be used with any PASCO Force Sensor to perform both elastic and inelastic collisions.

**Magnetic Bumper Set**

ME-9885A

Magnetic bumpers for use with any Force Sensor or Smart Cart to perform elastic collisions without any contact.

**Cart Adapter Accessory**

ME-6743

For constant velocity demonstrations and labs. It will roll at a constant velocity. When it reaches a wall, it flips over and changes direction.

**Photogate Brackets - IDS**

ME-9806

The Photogate Bracket is designed to attach Photogate Head to PATrack and Curved PATrack.

**Cart Replacement Axles**

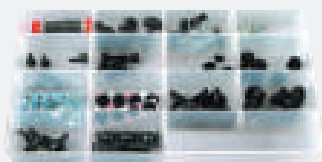
ME-6957

Replacement axles for PASCO dynamics carts. Compatible with all PASCO cart models, except the patented Smart Cart.

**Braided Physics String**

SE-8050

This string is tough, resists stretching, and will not unravel. Provides 320 meters of string.

**Spares Kit - IDS**

ME-9823

This is a spares kit for PASCO's Classic Dynamics Systems, including introductory dynamics systems.

Rubber Cord for IDS System

ME-8986

Replacement rubber cord used with the Elastic Bumper (ME-8998). Also fits Air Track Bumper. 30m spool.

**Dynamics Track Mount**

CI-6692

Allows a rotary motion sensor to mount on a Dynamics Track and act as a high resolution bi-directional Smart Pulley.

**Track String Adapter**

ME-6569

This adapter connects a dynamics cart and track to a string loop. The string loop moves with the cart and allows a Rotary Motion Sensor to calculate the linear motion of the cart.

**Dynamics Track End Stop**

ME-8971

The Dynamics Track End Stops are used with PASCO tracks to prevent carts from rolling off the track. One side of each end stop contains magnets to repel the magnetic bumper of a cart.

**Angle Indicator**

ME-9495A

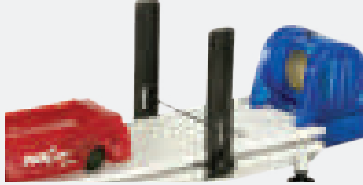
The Angle Indicator fastens to the T-slot of a dynamics track. Hanging plumb-bob indicates angle to $1/2^\circ$.



Compact Cart Mass

ME-6755

This 250-gram mass fits in many carts while a force sensor or spring cart launcher is mounted.



Elastic Bumper

ME-8998

The Elastic Bumper protects the Motion Sensor from the carts, but doesn't interfere with the ultrasonic pulse.



Cart Mass (set of 2)

ME-6757A

These 250-gram masses fit in any Dynamics Cart (including the Smart Cart) or the Discover Friction Accessory.



Super Pulley with Clamp

ME-9448B

Upgrade force tables and inclined planes with this pulley and clamp.



Dynamics Track Spring Set

ME-8999

For use with Dynamics Track Systems. These springs also work well for oscillating magnets in a solenoid driven by a Genecon hand-crank generator.



Harmonic Springs (8 pack)

ME-9803B

Includes eight identical springs: 8 cm long, 3.4 N/M spring constant.

Dynamics Systems Measurement

Smart Gate

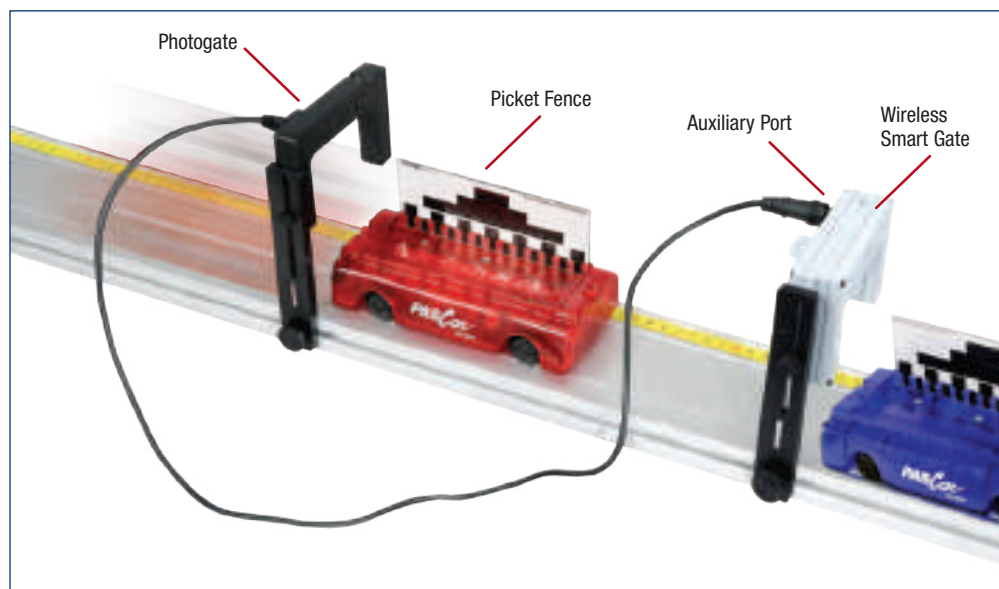
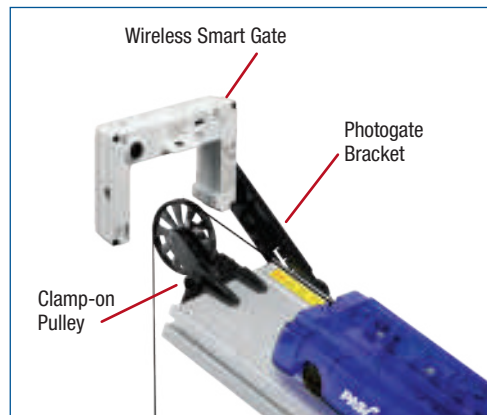
PS-2180

The Smart Gate connects directly to any PASPORT interface, and has an auxiliary port to daisy chain to an additional Photogate. It can be used with cart picket fences, Clamp-On Super Pulley, and flexible Photogate Tape.

Wireless Smart Gate

PS-3225

The Wireless Smart Gate has all the features of the Smart Gate (PS-2180), but it connects to your computing device via Bluetooth® or USB; it does not require an interface.



Smart Pulley

Use the Smart Gate and Photogate Bracket with the Clamp-on Super Pulley to create a “smart pulley.”

Double Infrared Beams

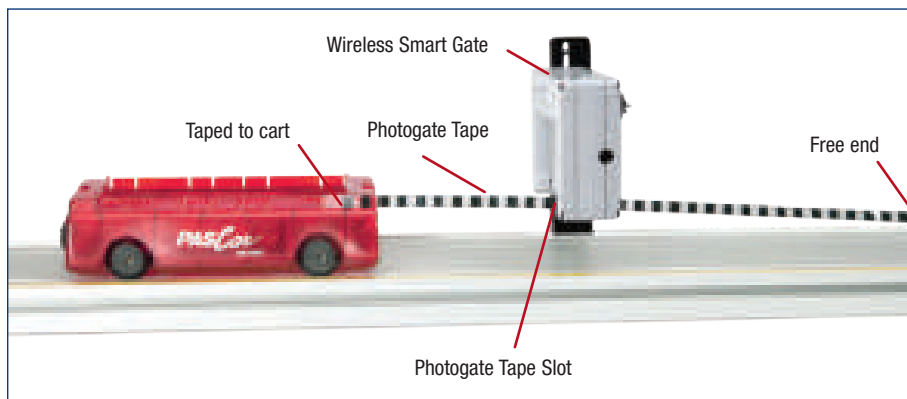
With the Smart Gate’s double beam, the velocity of a cart can accurately be determined using the front edge of a single flag.

Auxiliary Port

Here, a second photogate is connected to the Wireless Smart Gate Auxiliary Port.

Photogate Tape Slot

The Smart Gate has a special slot through which the Photogate Tape can be threaded. This creates an excellent way of continuously measuring the speed of the cart as it accelerates down the inclined track.



PS-2180 Includes:

- Smart Gate
- PASPORT Cable
- Interface Cord



PS-3225 Includes:

- Wireless Smart Gate
- USB Charge Cable



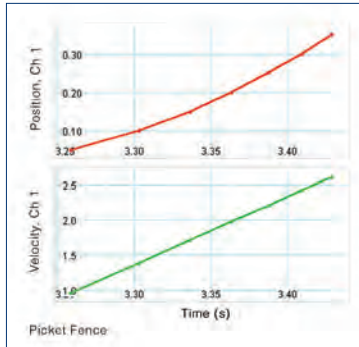
Order Information

Smart Gate	PS-2180	p. 32
Wireless Smart Gate	PS-3225	p. 54
Recommended:		
Photogate Head	ME-9498A	p. 33
Photogate Tape, High Resolution (30 m)	ME-6666	p. 33
Photogate Brackets (2 pack) – IDS	ME-9806	p. 123
Cart Picket Fences (2 pack) – IDS	ME-9804	p. 33
Super Pulley with Clamp	ME-9448B	p. 149

Photogates and Fences Dynamics System

ME-9471A

When used with a computer for data recording, display, and analysis, the photogate/pulley timing system provides a wide range of time, speed, and velocity measurements. The Photogates mount to the dynamics track using the provided brackets. The Picket Fences provided mount directly to the Dynamics Carts.



Position and velocity graphs are obtained using a Picket Fence and Photogate.

Includes:

- Photogate Heads (2)
- Photogate Brackets (2)
- Picket Fences (2)
- Super Pulley with attachment screw (attaches Super Pulley to Photogate)
- Pulley Mounting Rod

Order Information

Photogates and Fences Dynamics System	ME-9471A	
Individual Components:		
Photogate Head	ME-9498A	p. 33
Photogate Brackets (2 pack) – IDS	ME-9806	
Cart Picket Fences (2 pack) – IDS	ME-9804	
Super Pulley	ME-9450A	p. 149
Pulley Mounting Rod	SA-9242	p. 149
Required for use with PASPORT interfaces:		
PASPORT Digital Adapter	PS-2159	p. 50

Wireless Smart Gate Dynamics System

PS-3703

The Wireless Smart Gate Dynamics System provides a wide variety of time, speed, and velocity measurements. Mount the Photogates to a Dynamics Track using the included brackets. Use the Picket Fences to track Dynamics Carts.

Includes:

- Wireless Smart Gate: PS-3225
- Photogate Head: ME-9498A
- Photogate Brackets: ME-9806
- Picket Fences: ME-9804



Order Information

Wireless Smart Gate Dynamics System	PS-3703
---	---------

Photogate Brackets (2 pack) – IDS

ME-9806

- ▶ Attaches Photogates to PASCO Dynamics Tracks
- ▶ Easily Adjust Photogate Height

The Photogate Bracket allows the Photogate Head to be attached directly to PASCO dynamics tracks. This eliminates the need for separate photogate stands and allows the photogate height to be easily adjusted relative to the track. Includes two Photogate Brackets.



(Photogates not included.)

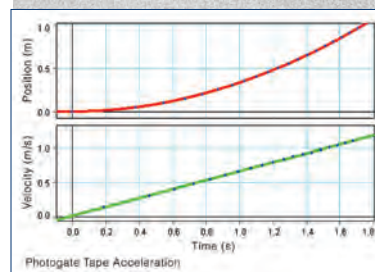
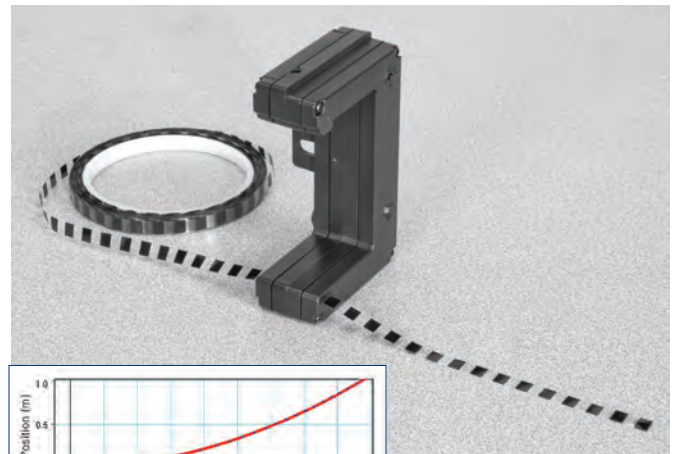
Order Information

Photogate Brackets (2 pack) – IDS	ME-9806
---	---------

Photogate Tape, High Resolution (30 m)

ME-6666

Cut this flexible Mylar Picket Fence Tape to any length and slide it into a Smart Gate to more accurately measure the motion of a cart.



Photogate tape can be used as a picket fence "string" to continuously measure the motion of the cart.

Slide the Photogate Tape through the slot to measure position, velocity, and acceleration. The band spacing on the tape is 1 cm from edge to edge.

Order Information

Photogate Tape, High Resolution (30 m)	ME-6666	
Required:		
Smart Gate	PS-2180	p. 32
Wireless Smart Gate	PS-3225	p. 54

Timers

The Most Versatile Stand-Alone Timer Available

Smart Timer

ME-8930

- ▶ Portable timer for photogates and smart pulleys
- ▶ Measures time, speed and acceleration
- ▶ Counter for G-M Tubes
- ▶ Crystal-controlled 0.01% accuracy

The ME-8930 Smart Timer works with all PASCO timing devices:

- ▶ Accessory Photogate
- ▶ Photogate/Pulley System
- ▶ Time-of-Flight Accessory
- ▶ Freefall Adapter
- ▶ Laser Switch
- ▶ G-M Tube

Measure Time:

- ▶ One Gate: Returns time from leading edge to leading edge
- ▶ Fence: Returns 10 time values
- ▶ Two Gates: Returns time between two gates
- ▶ Pendulum: Measures pendulum period
- ▶ Stopwatch: Returns time between pressing Start/Stop button

Measure Speed:

- ▶ One Gate: Single object speed using picket fence
- ▶ Collision: Initial and final speeds for one or two carts
- ▶ Pulley: Angular speed

Measure Acceleration:

- ▶ One Gate: Direct measurement of acceleration using picket fence
- ▶ Linear Pulley: Acceleration of string
- ▶ Angular Pulley
- ▶ Two Gates: Object's average acceleration between two photogates

Measure Counts:

- ▶ Three timing intervals
- ▶ Manual mode counts until Stop is pressed
- ▶ Up to 5,000 counts/second
- ▶ Up to 9,999,999 total counts

2-line, 16-character Alphanumeric LCD

- ▶ Top Line: Measurement Description; Bottom Line: Numerical Values



Features:

- ▶ **Works with Two Photogates**
- ▶ **More Than Just a Timer:** Measures speed and acceleration as well as time.
- ▶ **Quick Setup:** Turn on the switch, plug in the photogates, and it's ready to use.
- ▶ **Portability or Plug-in:** The battery-operated (four "AA"s) Smart Timer can be used outside the classroom away from power outlets. It can also be operated on the 9 VAC adapter (included).
- ▶ **Calculation Lock-out Switch:** A switch inside the battery compartment disables the speed and acceleration modes. Timing modes are unaffected, and students are required to do their own calculations.

Specifications:

Resolution: 100 μ s**Accuracy:** 0.01% of full range of the measured time**Display:** 2-line, 16-character, alphanumeric LCD**Inputs:** Two 1/4" stereo phone jacks on side panel— TTL compatible**Power Requirements:** Four "AA" batteries (not included) or AC adapter (9 VDC, 500 mA) included

It's as easy as 1-2-3.

1. Measurement

Press this button to select the quantity to be measured: "Time," "Speed," "Accel," "Count" or "Test" will appear on the display.

2. Mode

Press this button to select the type of experimental setup. Each mode is shown in words on the display.

3. Start/Stop

Press Start. The Smart Timer "beeps," and waits for an event to occur. After the event, the Smart Timer displays a result.

Two Photogate Ports



Durable Positive-click Buttons



Typical Experiments

- ▶ Acceleration Due to Gravity*
- ▶ Newton's Second Law*
- ▶ Conservation of Momentum in Collisions*
- ▶ Rotational Inertia of a Disk & Ring*
- ▶ Acceleration Down an Incline
- ▶ Simple Harmonic Oscillator
- ▶ Oscillations on an Incline
- ▶ Springs in Series and Parallel
- ▶ Projectile Motion Using Photogates
- ▶ Time-of-Flight and Initial Velocity
- ▶ Determining the Acceleration Due to Gravity
- ▶ Counting Radiation with the G-M Tube

*Experiments require accessories listed on pages 33 and 33.

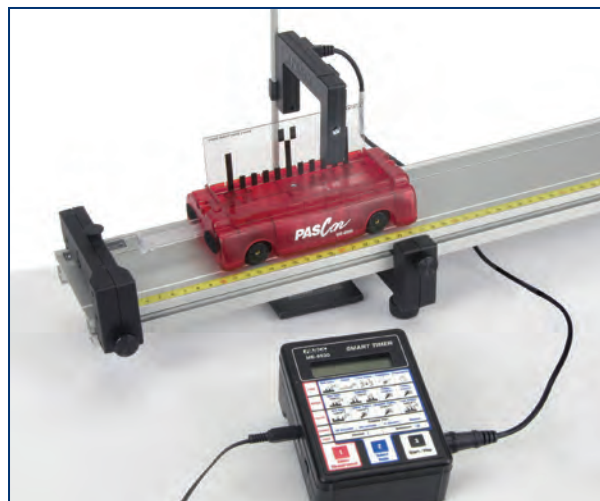


To see the experiments, type the product number into the search box at www.pasco.com and download the manual.

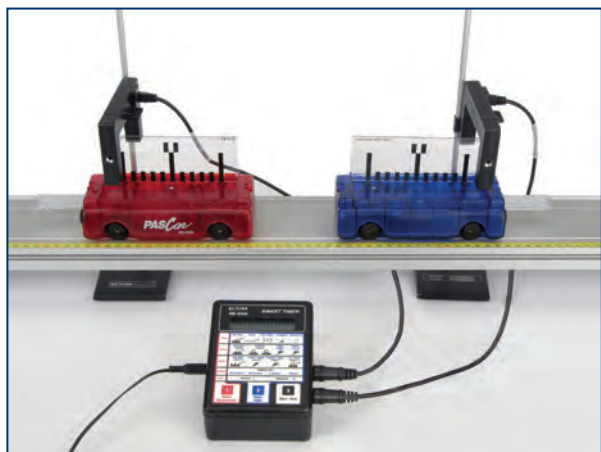
The microprocessor-based PASCO Smart Timer is the most versatile way to make time, speed, acceleration, and count measurements.



Speed of projectile—In Time: Two Gates mode; determine the speed of a ball fired by a Projectile Launcher through two photogates.



Speed of object through one gate—In Time: One Gate mode; timing begins when the photogate beam is first blocked and continues until the beam is blocked again. Use the fence supplied with the Smart Timer.



Speed before and after collision—In Speed: Collision mode; use two carts and two photogates with a single Smart Timer to measure initial and final speeds of both carts.



Rotary motion—In Acceleration: Linear Pulley mode; the Smart Timer measures the acceleration of the string over the Smart Pulley.

Includes:

- Smart Timer
- 9 VAC Adapter
- Picket Fences (2)
- Lab Manual

Order Information

Smart Timer.....	ME-8930	
Recommended:		
Accessory Photogate	ME-9204B	p. 27
Picket Fences (Smart Timer).....	ME-8933	
Freefall Adapter	ME-9207B	
Photogate & Pulley System	ME-6838A	p. 27
Time-of-Flight Accessory.....	ME-6810A	p. 27
Phone Jack		
Extender Cable	PI-8117	p. 27

Smart Timer Photogate System

ME-8932

The PASCO Smart Timer is among the most versatile and affordable measurement tools available to physics educators. This system includes a PASCO Smart Timer and two Photogates for measuring time, speed, acceleration, and count.

Includes:

- Accessory Photogate (2) ME-9204B
- Super Pulley ME-9450A
- Smart Timer ME-8930
- Picket Fences (Smart Timer) ME-8933
- 9 VAC Adapter and Lab Manual (not shown)



Order Information

Smart Timer	
Photogate System.....	ME-8932

Timers

Digital Photogate Timer System

ME-9403A

- High accuracy and resolution
- Four timing modes: gate, pulse, pendulum, and manual stopwatch
- Built-in memory
- Two Photogates for measuring time between gates

PASCO Photogates and Digital Timers are used in thousands of physics labs throughout the world because they are rugged and simple to operate.

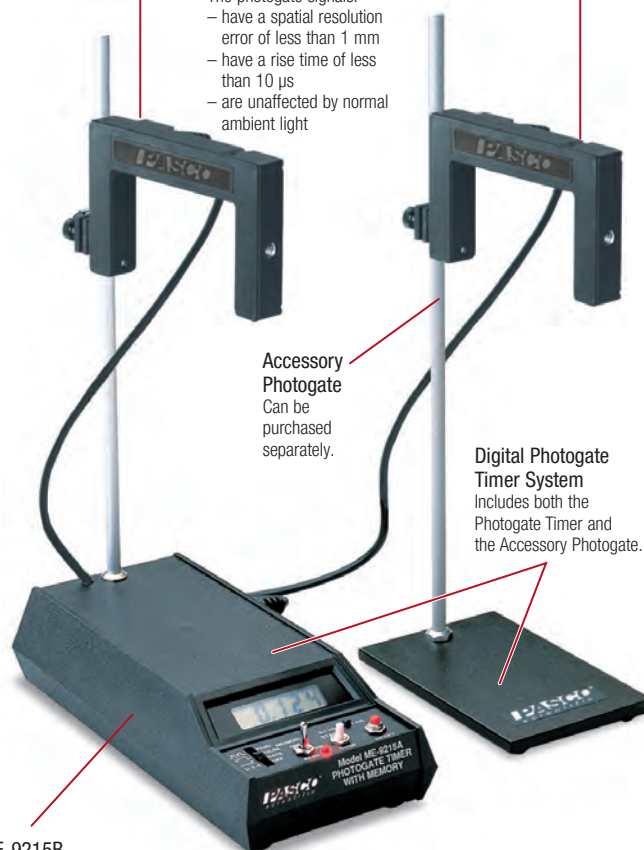


Precision Photogates

PASCO photogates are highly accurate timing devices. Each photogate has a high output, narrow angle infrared emitter and a narrow angle detector.

The photogate signals:

- have a spatial resolution error of less than 1 mm
- have a rise time of less than 10 μ s
- are unaffected by normal ambient light



ME-9215B
Photogate Timer
with Memory

Specifications:

Modes: Gate, pulse, pendulum, manual stopwatch

Resolution: 0.1 ms (max time 19.9999 s)

Accuracy: 0.05% of full range of the measured time ± 1 digit

Display: 5-1/2 digit, 10 mm high LCD

Memory: Preserves displayed time while new time is measured

Photogate: 6.5 cm wide; fully adjustable swivel mount; LED trigger indicator; fall time <10 ns; spatial resolution <1 mm

Inputs: Accessory Photogates, or TTL-compatible signals; one photogate jack and a 9-V AC adapter jack (or four "C" size batteries) on back panel

Compatible with these PASCO products:

- Time-of-Flight Accessory
- Freefall Timer
- Laser Switch

Features:

- Timer serves as the base
- 0.1 ms resolution and 0.01% accuracy
- Memory Function allows two measurements to be made in rapid succession, such as pre-collision and post-collision velocities
- Two Photogates for measuring elapsed time between gate interferences
- Simply turn it on and begin collecting measurements
- Powered by 4 C batteries (not included) or the 9V AC adapter (included)
- Manual includes ten ready-to-use experiments



Order Information

Digital Photogate Timer System	ME-9403A
Photogate Timer	ME-9215B
Accessory Photogate	ME-9204B

Tape Timer

ME-9283

- Crystal-controlled
- Two frequencies (10 Hz and 40 Hz)
- Easy-to-read dots

Provides students with a visual demonstration of speed and acceleration. A moving object pulls a paper tape through the timer. The timer prints dots on the tape at equal time intervals. The result is a series of dots on the paper tape, representing the position of the object as a function of time.

From the dots on the tape, the distance traveled can be measured, and the average speed for each time interval can be calculated. Plotting position versus time enables students to determine the average speed. Plotting the average speed for each time interval versus time enables acceleration to be determined.

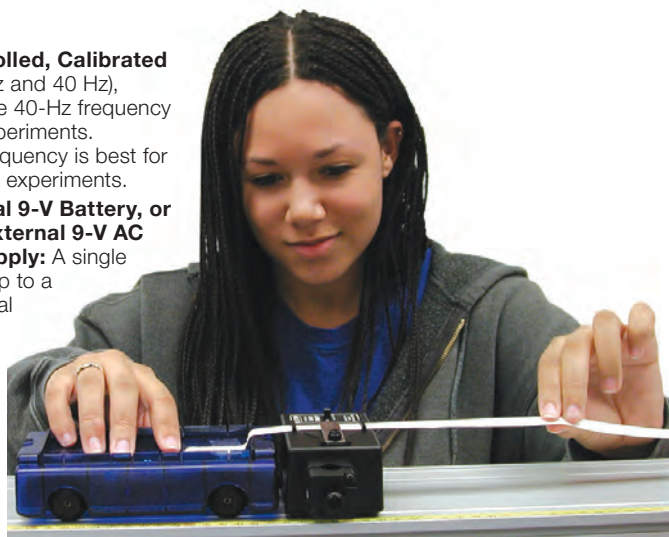
The paper tape can be attached to air track carts, dynamics carts, falling masses or other objects.

Features:

- **Two Crystal-controlled, Calibrated Frequencies:** (10 Hz and 40 Hz), accurate to 0.1%. The 40-Hz frequency is ideal for freefall experiments. The slower 10-Hz frequency is best for most dynamics track experiments.
- **Includes an Internal 9-V Battery, or Use an Optional External 9-V AC Adapter/Power Supply:** A single battery can last for up to a year's worth of normal experiments.
- **Low Mass, Small-pin Printing Head:** Driven by short millisecond pulses, produces sharp, round dots without smearing.
- **Plain Paper:** Print on 12.5 mm (1/2 inch) wide, plain paper supplied in 150-meter (500 feet) rolls.
- **Carbon Paper Discs:** Used for printing. The adjustable disc holder allows the printing point to be adjusted, giving a long life to the discs.
- **Rod Clamp:** Allows the Tape Timer to be mounted on a standard lab stand rod so that the paper path is either parallel or perpendicular to the rod. Rod sizes between 13 mm (1/2 inch) and 9 mm (3/8 inch) are accommodated.

Includes:

- Roll of paper
- Carbon paper discs
- Battery
- Manual (not shown)



PASCO Stopwatch

ME-1234

- No alarm or clock
- Memory for stored event times
- Uses one AA battery
- Durable buttons

Are you tired of annoying stopwatch alarms going off all day? Are your students stuck in the clock mode and can't get their stopwatch back into the timing mode? Does your stopwatch stop working after changing that little watch battery? The PASCO Stopwatch solves all these problems.

This stopwatch was designed specifically for science timing. The modes of operation are intuitive and complete instructions are included. The buttons are built to last and it uses a single long-lasting AA battery, which is less expensive than a watch battery (and easier to install).



The PASCO Stopwatch fits comfortably in your hand.



The EVENT/RECALL button allows you to view the last time, in case students forget to write down their data. The EVENT/RECALL button is also used to store and recall up to nine event times. For example, record a series of events, such as times at which sandbags were dropped along the gym floor.

Specifications:

LED Display: Visible indoors and outdoors
Two Display Modes: MM:SS.SS (01:25.34) or Decimal Sec (85.34 s)

Precision: 0.01 sec up to 59:59.99 (MM:SS.SS) or 3599.99 s Then 1 sec to 99:59:59 (HH:MM:SS) or 359999 s

Max Number of Event Times: Nine

Auto-off: After one hour idle

Can be used with a lanyard (not included)

Includes: One AA battery and instruction sheet

Order Information

PASCO Stopwatch.....ME-1234
 PASCO Stopwatch, 10-pack.....ME-1235

Order Information

Tape Timer.....ME-9283
 Recommended:
 Tape Timer Supplies.....ME-9284
 Includes five rolls of paper (150 m each) and 10 carbon discs.

Air Track

2.0 m Air Track

SF-9214

Variable Output Air Supply

SF-9216

- Nearly frictionless linear motion
- Two meters long
- Complete accessories included

It's simple physics—a moving object will continue forever at a constant velocity unless it's acted on by an external force. To the physicist, Newton's First Law is second nature. Yet it's still fascinating to watch an air track glider moving endlessly back and forth on an air track.

It's even more fascinating for students, who are often seeing this simple display of motion for the first time.

Add a timing system to investigate uniform motion, average and instantaneous velocities, uniform acceleration, elastic and inelastic collisions, impulse and change in momentum, conservation of momentum, conservation of energy, and more. The data is precise and unambiguous and frictional forces are negligible.

2-Meter Scale
Mounted to both
sides of track

Alignment Channel
Ensures that the track will
always be straight

Precision Cart
Designed to accept
accessories such as
flags, extra masses, etc.

Sturdy Design
Guarantees stability

Soft Bumpers
Reduce energy loss
during collisions

Accessory Kit

Soft bumpers reduce vibrations, allowing
elastic collisions that really are elastic.

Compared to other air tracks, the PASCO Air Track is:

- **Longer:** The full 2-meter length provides more room for experimenting (yet it still fits on a standard lab table).
- **Straighter:** Guaranteed straight to within 0.04 mm over its entire 2-meter length. If your air track should ever become misaligned, return it to us and we will realign it for free.
- **Tougher:** The track is a large square aluminum extrusion with 3 mm thick walls that are further strengthened by a supporting U-channel. This construction preserves straightness and allows for accurate realignment.
- **Quieter:** When using PASCO's Air Supply (SF-9216 Sold Separately) this system is exceptionally quiet (allows the air to be adjusted), and the variable flow provides the perfect amount of air for each experiment. (Too little air causes friction; too much air causes energy loss due to glider "flutter.")
- **Versatile:** The PASCO Air Track comes with a large set of accessories.
- **Precision Cart:** Designed to easily accept accessories such as flags, extra masses, etc.
- **2-Meter Scale:** Mounted to both sides of track.
- **Soft Bumpers:** Reduce energy loss during collisions.
- **Alignment Channel:** Ensures that the track will always be straight.

Specifications:

Length: 2 m (working distance 1.9 m)

Base: Three-point with bilateral leveling screws

Millimeter Scales: 2 meters long on each side

Includes:

- Gliders (2): 13 cm long; 170 g; with rubber-band bumpers
- Glider Flags (2): 25 mm
- Glider Masses (4): 50 g
- Glider Bumper (3)
- Inelastic Collision Kit: Needle with wax-filled receptacle
- Constant Acceleration Kit: Ball-bearing pulley, glider hook, mass hanger (2 g) and five acceleration masses: two 1 g; one 2 g; one 5 g; one 10 g
- Storage Case

Order Information

2.0 m Air Track SF-9214

Required:

Variable Output Air Supply.....SF-9216 p. 129

Recommended:

Replacement Parts..... see opposite page

Air Track Accessory Kit

SF-9295



A set of accessories comes with every PASCO Air Track. All that's needed is a timing system. The pieces of the set may be ordered separately.

Order Information

Air Track Accessory Kit..... SF-9295

Recommended:

Glider Kit..... SF-9224

Air Supply Hose for
Air Track (2m) SF-9298

Variable Output Air Supply

SF-9216



The PASCO Air Supply is exceptionally quiet. Its variable output lets students match the air flow to the experiment. A 2-meter hose is included. By adding the T-Adapter and Hose (SF-9217), the Air Supply can operate two PASCO Air Tracks at the same time.

Note: This Air Supply produces 36 cfm at 0.122 psi for use with the Precision Air Track SF-9214. If used with another track, the total area of the air flow holes must be greater than 2.6 cm², or the supply may overheat.

Order Information

Variable Output Air Supply.....SF-9216

Rubber Cord for IDS System (30m spool)

ME-8986



This rubber cord is used with PASCO's Elastic Bumper, and also fits the Air Track Bumper Set With Holder.

Order Information

Rubber Cord for IDS System
(30m spool) ME-8986

Air Track Accessories and Replacement Parts

The Air Track includes accessories for standard air track experiments, from simple acceleration to elastic and inelastic collisions. To add more advanced experiments, a variety of additional accessories are available.

Included in the SF-9295 Kit

(Each item may be ordered separately. The number in parentheses indicates how many of each item is included in the Accessory Kit.)

Mass/Hanger Set (1)

SF-6300



Bumper Set with Holder (3)

SF-6301



Bumper Set Air Track (3)

SF-6302



Inelastic Collision Needle (1)

SF-6303



Wax Receptacle (1)

SF-6304



Glider Hook (1)

SF-6305



Glider Mass (4)

SF-6307



Ball Bearing Pulley (1)

SF-6308



Photogate Flags (25 mm) (2)

SF-6311



Not Included in the SF-9295 Kit

(Must be ordered separately.)

Glider

SF-6306



Fixed End Stop

SF-6313



Adjustable End Stop

SF-6309



Glider Kit

(see photo below)

SF-9224

Air Supply Hose (2m)

SF-9298



Additional Glider Kit

SF-9224



Includes:

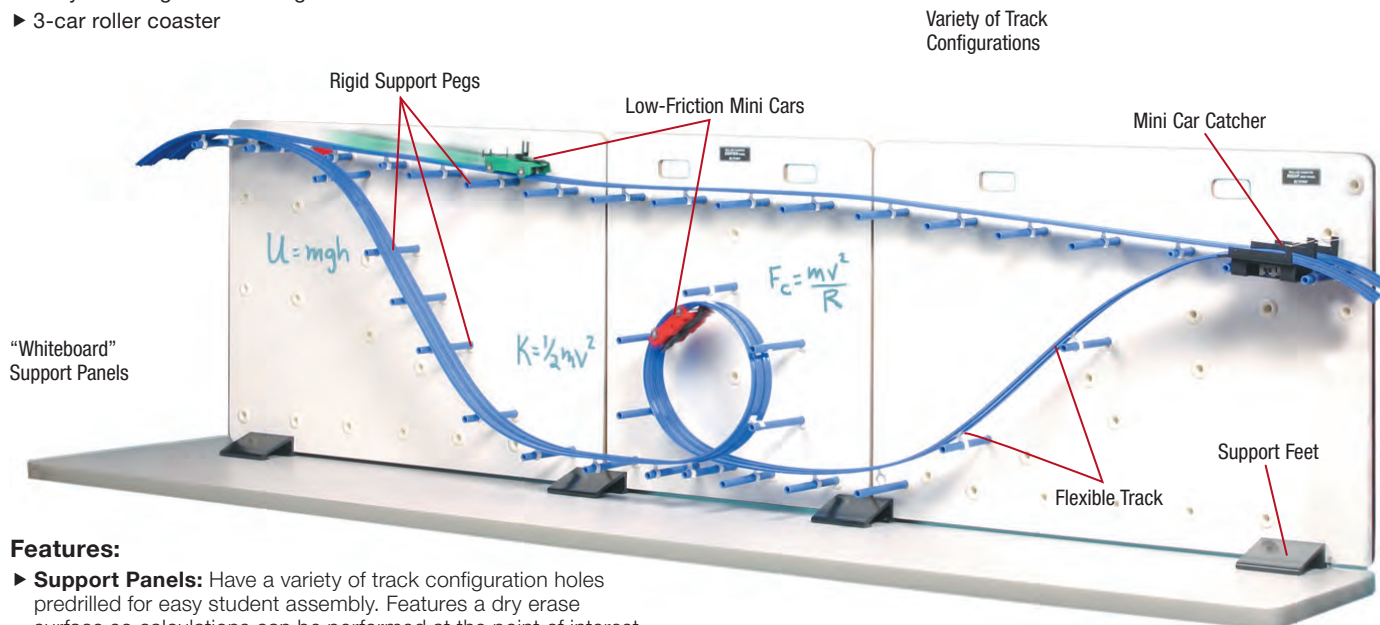
- Glider
- 50 g Masses (2)
- Bumper with Holder
- Bumper Blade

Roller Coaster

Roller Coaster Complete System

ME-9812

- Quantitative studies of Energy Conservation
- Easy to change track configurations
- 3-car roller coaster



Features:

- **Support Panels:** Have a variety of track configuration holes predrilled for easy student assembly. Features a dry erase surface so calculations can be performed at the point of interest on the track.
- **Mini Cars:** Have low-friction ball bearings and ABS construction to withstand repeated impacts. One red, one yellow and one green Mini Car included. Each car includes a slot for a supplied photogate flag, cup/mass holder and cup. The body of the car extends just far enough below the wheels to protect them should the car leave the track.
 - The Roller Coaster's Mini Cars are low friction, yet rugged; mass can be added to the cars on top or in the ballast position.
 - Bumpers mount on Mini Cars to allow rubber band or clay collisions. Also used to couple Mini Cars into a train.
- **Ballast Mass:** Can be added to the mass tray of a Mini Car or hidden under a Mini Car to increase the energy without changing the car's appearance.
- **Flexible track:** Guides carts on their path, yet is flexible enough to form loops and hills, or can be rolled out flat on a table. Easily attaches to the support pegs using the twist-on track clips. Long pegs allow two tracks side-by-side for comparison.
- **Probeware Compatible:** Threaded support pegs and Mini Car photogate flags allow photogates to be used at many positions around the track to measure velocity and acceleration.

Applications:

- **Conservation of Energy:** Release the Mini Car and measure its velocity and height at several points along the track. Use these values to calculate total energy of the Mini Car. Frictional losses are less than 5%.
- **Constant Acceleration:** Several straight inclined sections can be used to measure and demonstrate constantly accelerated motion.
- **Projectile Motion/Conservation of Energy:** Use the initial height of the Mini Car to determine its speed as it flies off the end of the track. Using this speed and height above the ground when it leaves the track, predict where the Mini Car will land.
- **Multi-car Train:** Mini Cars can be coupled to form a train and the velocity of each car can be measured with a photogate and a Smart Timer. The velocities are not the same.
- **Brachistochrone:** A Mini Car traveling between two points along a brachistochrone path takes less time compared to the straight line path.

Includes:

- Support panel (3 sections)
- Support feet (4)
- Flexible track (9.1 meters)
- Mini Cars (3)
- Support pegs for track (43)
- Photogate support pegs (4)
- Track clips (50)
- Mini Car catcher (2)
- Mini Car starter bracket (2)
- Mini Car collision accessory (3)
- Mini Car photogate flags (3)
- Water cup (3)
- Mini Car ballast mass (3)
- Photogate brackets (4)
- Track couplers (2)

Order Information

Roller Coaster Complete System.....	ME-9812	
Recommended:		
Photogate Head	ME-9498A	p. 33
Photogate Brackets (2 pack) – IDS.....	ME-9806	p. 123
Spares Kit – Roller Coaster	ME-9815	
Mini Cars (set of 3)	ME-9813	
Roller Coaster Track.....	ME-9814	
Smart Timer.....	ME-8930	p. 124

Loop-the-Loop

SE-7591

How high do you have to start the ball to make it go over the loop? Students use Conservation of Energy to determine how much potential energy is needed to have enough speed to make it around the loop.

Specifications:

Base Dimensions: 15 cm x 38 cm

Height: 52 cm

Loop Diameter: 14 cm

Includes:

- Two steel balls (1.9 cm dia.)
- Wooden base
- V-shaped aluminum track

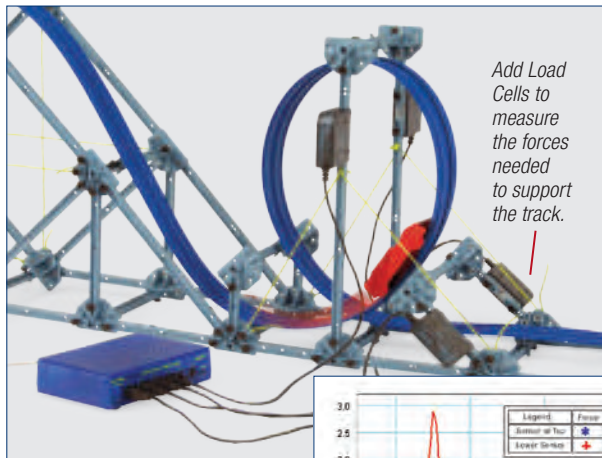


Order Information

Loop-the-Loop.....SE-7591

Design your own roller coaster with PASCO's Structures System.

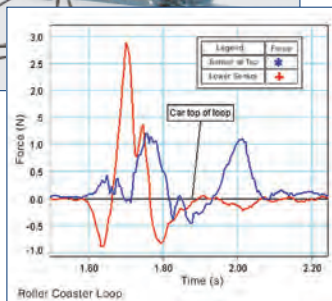
PASCO's Structures System allows students to design and build their own roller coaster for detailed studies of conservation of energy and centripetal force. The flexible track is perfect for building hills, valleys and even a loop! Car with low-friction, ball-bearing wheels minimizes energy losses. Measure the speed of the car using photogates or a Motion Sensor.



Add a loop to your roller coaster

Investigate the effect of changing the size and shape.

Graph shows support forces exerted on the track as the car goes up and over the loop.



Amusement Park Physics Kit

ME-9426A

- ▶ Extend your lab into the "real world"
- ▶ Complete kit for 15 students
- ▶ Developed in conjunction with AAPT

They might lose their notes. They might even lose their nerve. But in one day at an amusement park, students will also gain a real "gut-level" appreciation for Newton's Laws. Using this kit, students don't observe a dynamics cart. They are the dynamics cart. This is the only kit that is:

- ▶ Approved by the safety officers of major amusement parks across the USA.
- ▶ Student-tested in amusement parks by hundreds of schools.
- ▶ Teacher-tested in hundreds of Amusement Park Physics Workshops.
- ▶ Made with a metal coil spring for the Vertical Accelerometer (far more accurate than the commonly used rubber band).

Students experience the thrill of scientific investigation.

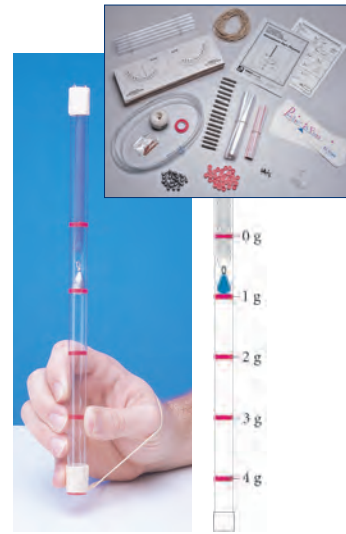


Photo courtesy of Paramount's Great America.

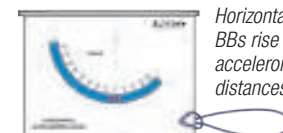
Includes:

- Brass Hanging Weights (19)
- Springs* $k = 3 \text{ N/m}$ (16)
- Plastic Tubing (2.5 m)
- Plastic Tubes, 30 cm long (16)
- Plastic Tube End Caps (32)
- Bumper Stickers (16)
- Horizontal Accelerometer
- Cards (16)
- Push Pins (5)
- No. 3 Paper Clips (17)
- Cotton String
- Metal Balls (60)
- Straws (16)
- Wire Ties
- Vinyl Tape
- Rubber Bands #117 (32)
- Rubber Bands #19 (6)
- Plastic Storage Bags (16)
- Instruction Manual

*Additional accelerometer springs may be purchased separately. See order information below.



Vertical Accelerometer: The stretch of the spring measures the vertical acceleration in "g's."



Horizontal Accelerometer: The angle to which the BBs rise measures the horizontal acceleration. This accelerometer doubles as a sextant to measure distances by triangulation.

Order Information

Amusement Park Physics Kit (15 pack)ME-9426A
Recommended:
Accelerometer Springs (16 pack)ME-8734
Scissors, pliers, masking tape, clear plastic tape

Hovercraft

Hovercraft

ME-9838

- ▶ Students experience Newton's Laws
- ▶ Durable nylon skirt
- ▶ Rubber bumper
- ▶ Optional cordless air supply

Our Hovercraft follows the classic design, with a rugged nylon skirt attached around a 1.2 m wood platform. Students can easily ride on the Hovercraft to experience firsthand the kinematics of frictionless motion.

How It Works

The nylon skirt is stretched around the wood platform and tightened using a steel wire.

The center of the skirt

is attached to the bottom of the wood platform. A custom rubber bumper is placed around the circumference of the wood platform. The bumper helps secure the skirt and also provides a soft cushion around the edge of the Hovercraft. A high-volume air source is used to force air through the platform and into the skirt. After sitting on the platform, the air source is turned on and the skirt inflates. Small holes in the skirt allow the air to escape, while providing the higher pressure needed to lift the rider. A built-in level helps students center their weight on the Hovercraft.

A Cordless Air Source (SE-8806) is orderable separately (below). In addition, most leaf blowers provide enough air flow to support the Hovercraft.

The PASCO Hovercraft is capable of supporting up to 300 lbs and comes completely assembled.



Air source
not included.

Hover Puck

SE-7335B

- ▶ Hovers on a cushion of air
- ▶ Ideal for inertia activities

The Hover Puck glides on a self-generated cushion of air across any smooth surface, including low-pile carpet. The rubber bumper provides protection for the puck and other objects during collisions. Each puck includes four "AA" batteries.



Specifications:

Diameter: 18.5 cm

Height: 6.0 cm

(Appearance may vary)

Includes:

- Hover Puck
- Four "AA" Batteries

Order Information

Hover Puck SE-7335B

Recommended:

PASPORT

Motion Sensor PS-2103A p. 34

Motion Sensor II CI-6742A p. 26

Wireless Motion
Sensor PS-3219 p. 53

Cordless Air Source

SE-8806



Includes:

- Rechargeable Battery
- Charging Adapter

Order Information

Cordless Air Source SE-8806

Double-Reinforced Nylon Skirt stretched around the wood platform and tightened using a steel wire prevents failure under high pressure loads.

Custom Rubber Bumper is stretched securely around the circumference of the wood platform.

Air Holes allow air to escape, providing high pressure to lift the student.

Includes:

- Wood platform (1.2 m diameter, 1.9 cm thick)
- Nylon skirt with mounting hardware
- Rubber bumper
- Liquid level
- Connection hose for air source



Order Information

Hovercraft ME-9838

Recommended:

Cordless Air Source SE-8806

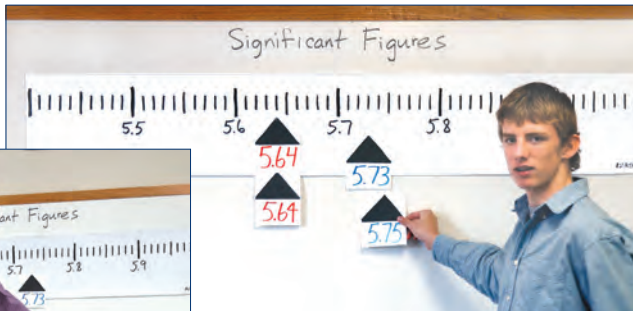
Significant Figures Set

ME-9850

- Connects measurements to Significant Figures
- Includes materials for one student group
- Detailed activity manual

The series of activities included in the Significant Figures Set emphasize the connection between measurements and significant figures. Students work through a number of situations in which they experience the concepts of accuracy and precision. Through these activities, students learn the importance of the measuring tool and its role in the uncertainty of measurements. For each activity, student groups are asked to place their measurements and/or calculations along a demonstration number line. The groups can then share their results with the entire class during discussions and presentations.

The Number Line and Data Pointers are laminated for use with dry erase markers.



The Ball Drop activity gives students experience with accuracy and precision.



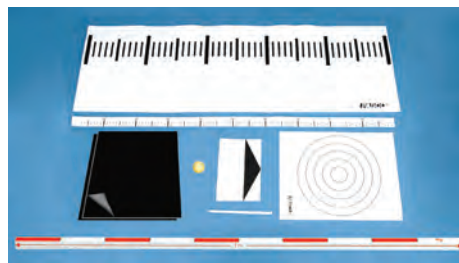
The Four-Scale Meter Stick is an important part of the Significant Figures Kit as it includes four scales of varying precision.

Perform These Experiments:

- **Ball Drop:** Students toss small balls on a bulls-eye to discover the relationship between technique and measurements. In addition, the concepts of accuracy and precision are explored.
- **“Forced Error” Measurements:** Students use a meter stick that has inaccurate markings to take measurements to reinforce that precise measurements are not always accurate.
- **Mass/Length Measurements:** Students use a balance or Four-Scale Meter Stick with imprecise scales to limit the certainty in their measurements.
- **Area/Volume/Density Calculations:** Students use a variety of measuring devices to calculate the area, volume, and density of various objects.

Includes:

- Yellow Nylon Ball
- Paper Bullseye (2)
- Carbon Paper (100 Sheets)
- Four Scale Meter Stick
- Number Line
- Data Pointer
- Meter Stick Label
- Balance Label



Order Information

Significant Figures Set ME-9850

Discover Pi Set

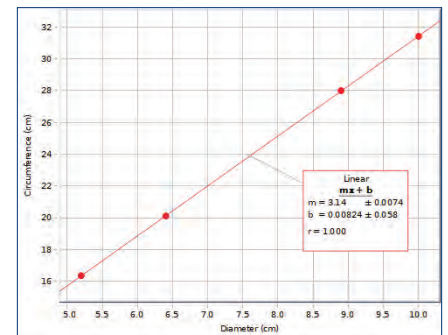
ME-6806

- Students discover the meaning of Pi
- Pi circles stack together for easy storage



The student reads the circumference directly from the transparent tape wrapped around the pi circle.

The Discover Pi Set allows students to derive the meaning of pi directly from their measurements. This activity transforms pi from a constant with unknown origin to a fundamental characteristic of all circular objects.



The slope of the circumference vs. diameter graph is equal to π .

Includes:

- 4 Disks of different diameters (5.2, 6.4, 8.9, 10.0 cm)
- Transparent Measuring Tape (2)
- Adhesive Stops (2)

Order Information

Discover Pi Set ME-6806

Gravity & Freefall

Discover Freefall System

ME-9889

- Determine g
- Investigate air resistance dependence on mass, volume, cross-sectional area

PASCO's Discover Freefall System can be used to drop almost any small object by attaching a small steel washer with a small adhesive pad (both are included in the system). Using an electric switch, timing is started automatically, just as the object is dropped. And the Time-of-Flight Pad stops timing when the object strikes it.

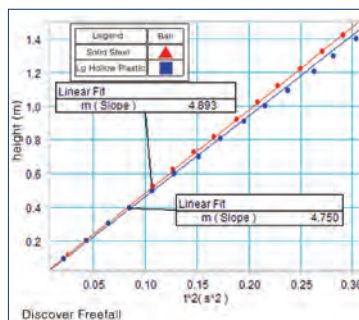
Students can investigate the effect of air resistance on acceleration. In addition, students can drop objects of the same size but different mass to study how object mass affects terminal velocity during freefall. The drop box has a magnetic mount for attaching to metal frames in ceilings.



This system can also accept the Target Accessory, ME-6853, to perform the shoot-the-target demonstration. See page 139.

**Includes:**

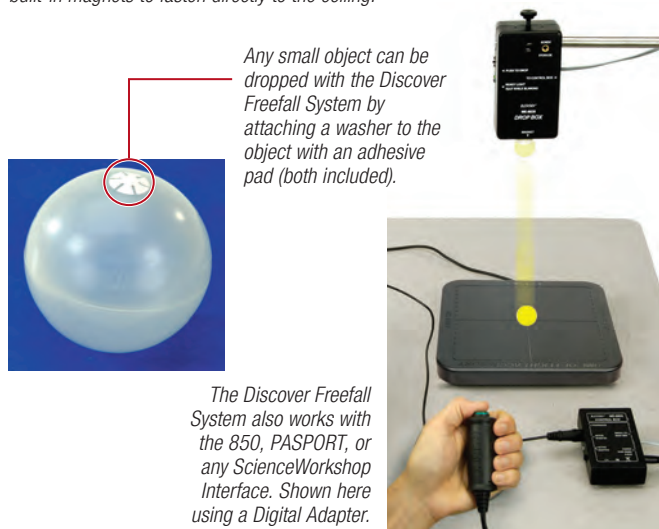
- Drop box
- Control cable
- Control box
- AC adapter
- Time-of-Flight receptor pad
- Timer Switch
- Release washers (10)
- Release labels for attaching washers to object (50)
- Small nylon ball
- Large plastic ball
- Golf ball
- Hollow golf ball
- 1" steel ball
- 5/8" steel ball



When the switch is pressed, the ball is dropped and the time of fall is measured for various balls. The graph shows height vs time-squared data for the 1 inch steel ball and the large hollow plastic ball. The slope of the line (equal to $1/2 g$) gives an acceleration for the steel ball of 9.79 m/s^2 . Note that the acceleration of the large hollow ball is considerably smaller and that its data is not linear.



Shown in use with rods and clamps sold on pages 196-199. The Drop Box also has built-in magnets to fasten directly to the ceiling.



The Discover Freefall System also works with the 850, PASPORT, or any ScienceWorkshop Interface. Shown here using a Digital Adapter.

Order Information

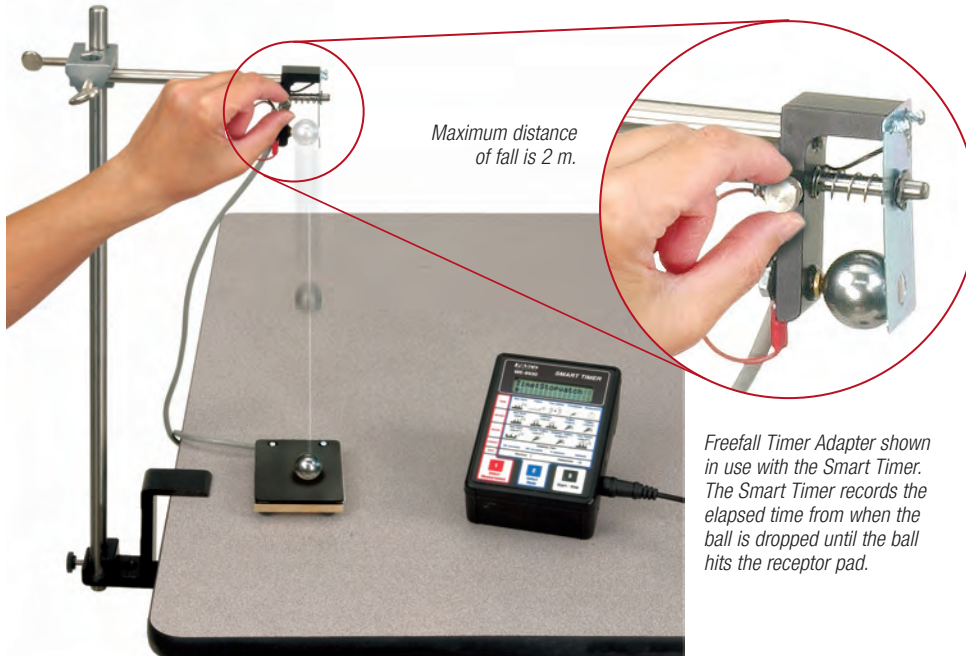
Discover Freefall System.....	ME-9889	
Required:		
Smart Timer.....	ME-8930	p. 124
or 850/550 Interface.....		pp. 20-22
Recommended:		
Freefall Balls Accessory	ME-9890	p. 211
Rods and Clamps.....		pp. 204-207
Also Available:		
Timer Switch	ME-9819	

Freefall Adapter

ME-9207B

How it Works:

A steel ball is clamped into a spring-loaded release mechanism. At the instant the ball is released, the electronic timer automatically starts. The timer stops when the ball hits the receptor pad. With the accurate, high resolution timing and automatic start and stop, the resulting measurements of "g" are precise and repeatable.

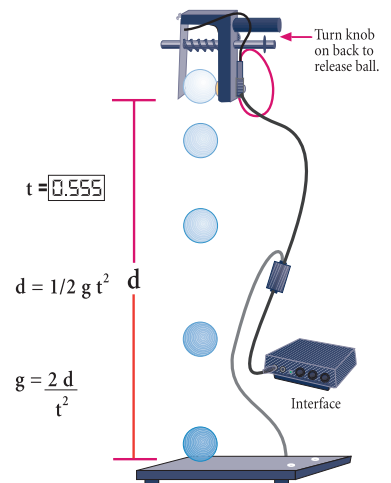


Maximum distance
of fall is 2 m.

Freefall Timer Adapter shown
in use with the Smart Timer.
The Smart Timer records the
elapsed time from when the
ball is dropped until the ball
hits the receptor pad.

Designed for use with any of the following:

- ▶ 850 Universal Interface (UI-5000)
- ▶ 550 Universal Interface (UI-5001)
- ▶ Smart Timer (ME-8930)
- ▶ Photogate Timer (ME-9215B)
- ▶ AirLink (PS-3200) with Digital Adapter (PS-2159)



Includes:

- Ball release mechanism with stereo phone plug and receptor pad
- Four steel balls (1.9 cm, 1.6 cm diameter)



Order Information

Freefall Adapter	ME-9207B	
Required:		
Large Table Clamp	ME-9472	p. 207
Multi-Clamp	ME-9507	p. 206
90 cm Stainless Steel Rod	ME-8738	p. 204
Photogate Timer	ME-9215B	p. 126
Smart Timer	ME-8930	p. 124
or 850/550 Interface		pp. 20-22

Drop-Shoot Demo

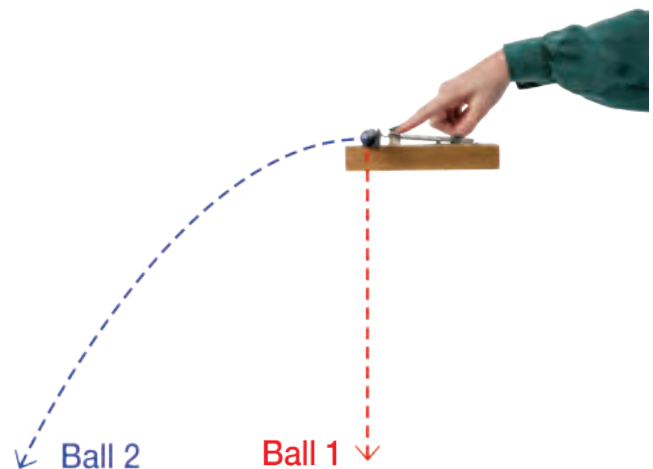
SE-7592A

- ▶ Demonstrates the independence of horizontal and vertical components of projectile motion

Pushing down on the lever releases the spring, causing one ball to drop directly down while the other is projected horizontally. Listen and you'll hear that both hit the floor at the same time! This demonstrates that each ball accelerates the same in the vertical direction, independent of their horizontal motion.

Includes:

- Drop-shoot mechanism
- Steel balls (2)



Order Information

Drop-Shoot Demo	SE-7592A
-----------------------	----------

Launchers

Projectile Launcher

ME-6800

- Accurate
- Durable
- High Repeatability



Three Repeatable Launch Ranges visible through viewing ports

2.5 cm Nylon Balls

Loading Rod

Plumb Bob indicates angle to 1/2°

Stable Launcher Base offers horizontal and variable angle launching positions

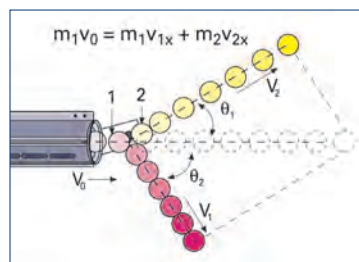
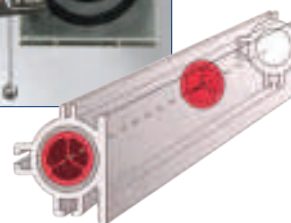
Unique Sights

Shoot-the-Target

The "gun" is aimed directly at the target. Although the target "drops" the moment the projectile is fired, the ball still hits the target since the ball falls with the same acceleration.



Two bore sights simplify aiming the launcher.



The 2-D Collision Accessory (included with all PASCO launchers) allows the study of **Conservation of Momentum** in two dimensions. Use the points of impact with the floor of each of the two balls to determine relative velocities and angles.

Specifications:

Ranges: 1.2, 3, 5 m

Launch Angles: 0 to +90°

Launcher Length: 21 cm

Features:

- **Variable Launch Speed:** For short range or longer range experiments.
- **Fixed Firing Height at Any Launch Angle:** Firing height of ball is same for any launch angle.
- **Unique Piston Design:** Minimizes projectile spin to ensure repeatability of impact position.

Includes:

- Projectile Launcher
- Launcher Base
- Projectile Balls (2)
- Loading Rod
- Safety Glasses
- 2-D Collision Accessory
- Manual

Order Information

Projectile Launcher.....	ME-6800	
Shown in use with:		
Shoot-the-Target	ME-6853	p. 139
Photogate Mounting Bracket.....	ME-6821A	p. 141
Smart Gate	PS-2180	p. 32
Recommended:		
Time-of-Flight Accessory	ME-6810A	p. 141
Large C Clamp (6 pack)	SE-7285	p. 141
Plumb Bobs (10 pack)	SE-8728	p. 141

Launcher Spares Kit

ME-6802

Contains spare equipment for the PASCO Projectile Launcher.

Includes:

- Loading Rod (10)
- 2-D Collision Accessory (2)
- Plastic Balls (10)
- Sights (5)
- Angle Indicator (1)
- Plumb Bobs (12)
- Thumbscrew to attach launcher to base (10)



Order Information

Launcher Spares Kit.....ME-6802

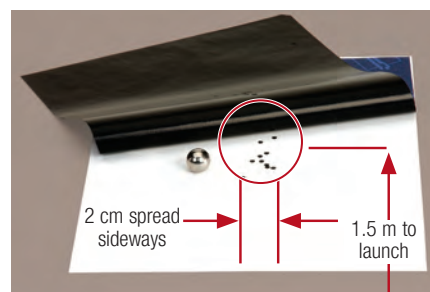
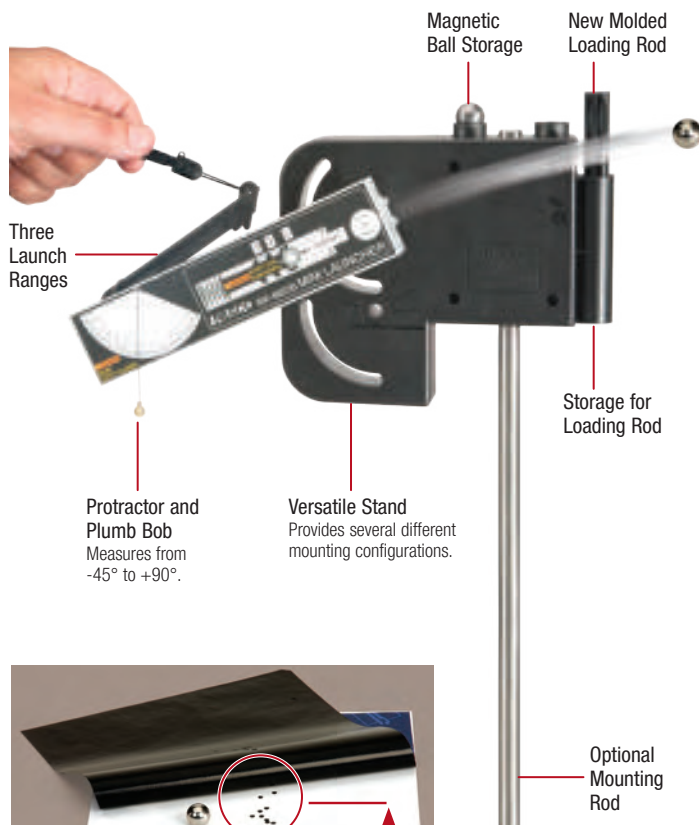
Mini Launcher

ME-6825B

- Ideal for tabletop projectile experiments
- Fires at downward angles
- Low cost

Bracket features include:

- Magnetic ball storage
- New plunger storage
- Labeled shooting positions



Typical pattern for Mini Launcher –
Ball was launched 10 times off 1 m high table at 30° angle. All 10 shots landed within 5 cm diameter circle.

Mini Launcher Spares Kit

ME-6824

Includes several spare parts for Mini Launcher.

Includes:

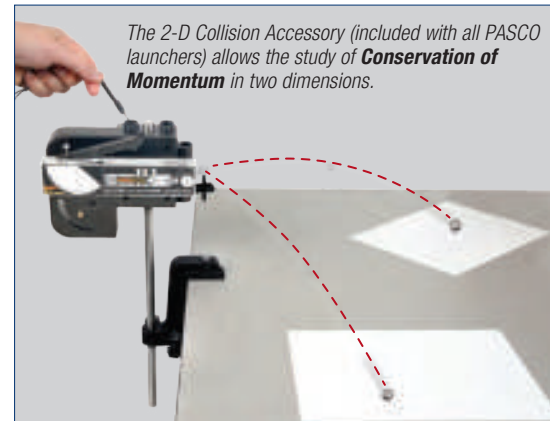
- Loading Rod (10)
- 2-D Collision Accessory (2)
- Steel Balls (10)
- Angle Indicator
- Plumb Bobs (12)
- Thumbscrew to attach launcher to base (10)



Order Information

Mini Launcher Spares KitME-6824

2-D Collision



Shoot from tabletop level!



Unique stand design allows ball to be launched from tabletop height. The ball lands on the table at the same height from which it was launched.

Magnetic Piston holds ball in place for launching at downward angles.



Negative launch angle!

Specifications:

Range: 0.5, 1, 2 m

Launch Angle: 0 to $+90^\circ$ and 0 to -45°

Launcher Length: 18 cm

Includes:

- Launcher Base
- Loading Rod
- 2-D Collision Accessory
- Steel Ball Projectile, 16 mm (2)
- Safety Glasses
- Manual
- Mini Launcher

Order Information

Mini Launcher.....	ME-6825B	
Recommended:		
Photogate Mounting Bracket.....	ME-6821A	p. 141
Smart Gate	PS-2180	p. 32
Time-of-Flight Accessory	ME-6810A	p. 141
Large C Clamp (6 pack)	SE-7285	p. 141
45 cm Stainless Steel Rod	ME-8736	p. 204
Plumb Bobs (10 pack).....	SE-8728	p. 141
Carbon Paper (100 sheets).....	SE-8693	p. 141
30 Meter Measuring Tape	SE-8712A	p. 208

Launchers

Projectile Motion Kit

ME-1262



Perform These Experiments:

- ▶ Projectile Motion
- ▶ Projectile Motion Using Photogates
- ▶ Projectile Range versus Angle
- ▶ Projectile Path
- ▶ Conservation of Energy of a Projectile Launched Straight Up
- ▶ Conservation of Momentum in Two Dimensions
- ▶ Varying Angle to Maximize Height on a Wall
- ▶ Horizontal Speed of a Projectile
- ▶ Horizontal Distance of a Projectile
- ▶ Time of Flight Versus Initial Speed

This kit has everything you need to perform classic projectile motion experiments by marking landing points of the ball using carbon paper and measuring the starting height and the horizontal distance traveled with a meter stick.

In addition, students can measure the initial speed of the ball using a photogate and measure the time-of-flight as the ball hits the pad which is plugged into the photogate.



Examine how the range is affected by launch angle. The Mini Launcher is ideal for table-top experiments because its bracket allows it to launch the ball from table-top level.



Every PASCO projectile launcher includes a 2-D Collision Accessory which holds a second ball at a position just outside the muzzle so that the ball being launched from the projectile launcher will strike the second ball. This two-dimensional collision causes the two balls to strike the table at different places. Students can measure the distances and the angles to determine the velocities of the balls after the collision and can perform conservation of momentum calculations.

This apparatus can even be used to do a simple Conservation of Energy experiment. The launcher is pointed straight up and the students measure the initial speed of the ball as it is launched and the maximum height the ball achieves as kinetic energy is turned into gravitational potential energy.

Includes:

- Mini Launcher ME-6825B
- Time-of-Flight Accessory ME-6810A
- Photogate Mounting Bracket ME-6821A
- Wireless Smart Gate PS-3225
- Aluminum Meter Stick
- C-Clamp
- Carbon Paper
- Plumb Bob



The Mini Launcher has a magnet in the piston to hold the ball when the launcher is set to a negative angle.



Order Information

Projectile Motion Kit..... ME-1262

Also Available:

Mini Launcher Wireless

Smart Gate System..... ME-6796

Shoot-the-Target

ME-6853

- Demonstrate independence of x- and y-motion
- For use with all launchers

The PASCO Shoot-the-Target Accessory, in combination with a Projectile Launcher, demonstrates that acceleration is constant for all objects in freefall, regardless of initial velocity. A target is initially suspended near the ceiling, and a Projectile Launcher is aimed directly at it. As soon as the projectile is shot from the launcher, the target is released. The projectile hits the target as it falls, proving that both objects accelerate downward at the same rate.

Before it falls, the target is attached to the drop box by a permanent magnet so it can hang indefinitely, even when the drop box is not powered. A photogate detects the projectile as it leaves the launcher and triggers the drop box. The drop box releases the target by driving a current through a coil that cancels the field of the permanent magnet.

The "gun" is aimed directly at the target. Although the target "drops" the moment the projectile is fired, the ball still hits the target. Both the ball and the target fall with the same acceleration.

Includes:

- Drop Box & Control Box
- Control Cable
- Target ME-6852
- Photogate Head & Bracket
- AC Adapter (9 VDC, 500 mA)



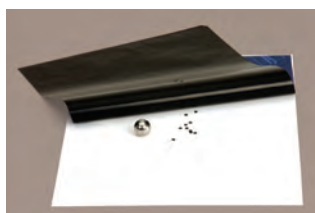
Order Information

Shoot-the-Target	ME-6853	
Recommended:		
Projectile Launcher	ME-6800	p. 136
Mini Launcher	ME-6825B	p. 137

Carbon Paper (100 sheets)

SE-8693

Carbon paper is ideal for marking the position of an object as it strikes the floor or other surface.



Time-of-Flight Accessory

ME-6810A

- For use with all PASCO launchers

Includes:

- Time-of-Flight Accessory
- Instruction Manual
- Experiment Guide



Order Information

Time-of-Flight Accessory	ME-6810A
--------------------------------	----------

Order Information

Carbon Paper (100 sheets)	SE-8693
---------------------------------	---------

Launcher Accessories

Drop Shoot Accessory

ME-9859

- ▶ Simultaneously drops one ball and launches a second ball horizontally
- ▶ Proves the independence of x- and y-motion
- ▶ Mounts on PASCO projectile launchers (short- and long-range)

The Drop-Shoot Accessory is an easy-to-use tool that helps students better understand the independence between the horizontal and vertical motion of a projectile. Connect the accessory to either the short or long range projectile launchers, hang one ball from the magnet and fire away. The fired ball strikes the hanging ball, causing one ball to shoot horizontally at the same instant the other ball falls straight down. Both balls hit the ground at the same time, regardless of the fired projectile's muzzle velocity, provided the Projectile Launcher is level. This device also provides an interesting demonstration of Conservation of Momentum in collisions.

When the (included) hollow steel ball is used, the two balls are both fired horizontally at two different speeds. A Photogate and Time-of-Flight Accessory can also be used to directly measure time of flight.

Includes:

- Drop-Shoot Bracket
- 2.5 cm Steel Balls (2)
- 2.5 cm Hollow Steel Ball
- Mounting Hardware
- Loading Rod



When the solid ball hits the hanging solid ball, the hanging ball shoots out horizontally, while the ball shot out of the launcher drops straight down.

Either the solid steel ball or hollow steel ball is hung by a magnet.



Order Information

Drop Shoot Accessory	ME-9859	
Required:		
Projectile Launcher	ME-6800	p. 136

Ball Catcher

ME-1252

The Ball Catcher can be mounted on a dynamics cart or a rotating meter stick to catch a ball shot from a projectile launcher.

The Ball Catcher has adjustable sides to accommodate 1-inch steel or plastic balls from the Projectile Launcher (ME-6800) or 5/8-inch steel balls from the Mini Launcher (ME-6825B).

The Ball Catcher fits into any PASCO dynamics cart or Smart Cart has a screw to attach it to the bed of the cart.

Perform These Experiments:

- ▶ **Conservation of Linear Momentum:** Shoot a ball into the Ball Catcher on a dynamics cart
- ▶ **Conservation of Angular Momentum:** Shoot a ball into the Ball Catcher on a horizontally rotating meter stick
- ▶ **Ballistic Pendulum:** Shoot a ball into the Ball Catcher on a meter stick pendulum



Includes:

- Ball Catcher
- Mounting screw

Order Information

Ball Catcher	ME-1252
--------------------	---------

Time-of-Flight Accessory

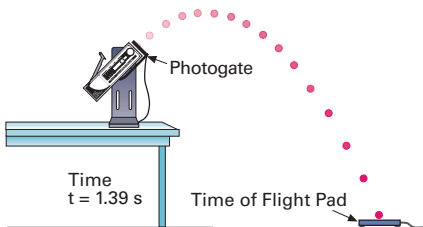
ME-6810A

► For use with all PASCO launchers

The Time-of-Flight Accessory is designed primarily for freefall or projectile experiments. When an object hits the plate, a signal is sent to the interface.



Note: When used with the Projectile Launcher, a photogate is used to start the timer and the 20' extension cable is recommended.



Includes:

- Time-of-Flight Accessory
- Instruction Manual
- Experiment Guide

Order Information

Time-of-Flight Accessory ME-6810A

Photogate Mounting Bracket

ME-6821A



Mount one or two photogates on any Projectile Launcher. Compatible with the Photogate Heads below.



Order Information

Photogate Mounting Bracket ME-6821A
Photogate Head ME-9498A p. 33
Accessory Photogate ME-9204B p. 27
Smart Gate PS-2180 p. 32
Wireless Smart Gate PS-3225 p. 54

Small Steel Balls (10 pack)

ME-9872



These 1.6 cm diameter steel balls are used with the Mini Launcher (ME-6825).

WARNING
CHOKING HAZARD
Contains small balls. Not for children under 3 years.

Order Information

Small Steel Balls (10 pack) ME-9872

Steel Balls (4 pack)

ME-9864



WARNING
CHOKING HAZARD
Contains small balls. Not for children under 3 years.

Purchase this 4 pack of 2.5 cm diameter balls for use with PASCO Short or Long-Range Projectile Launchers (ME-6800 or ME-6801).

Order Information

Steel Balls (4 pack) ME-9864

Plastic Balls (10 pack)

ME-6822



WARNING
CHOKING HAZARD
Contains small balls. Not for children under 3 years.

These extra brightly colored balls are designed for the Projectile Launcher. Diameter is 2.5 cm (1 in.).

Order Information

Plastic Balls (10 pack) ME-6822

Spherical Mass Set

ME-8968



WARNING
CHOKING HAZARD
Contains small balls. Not for children under 3 years.

This set includes four balls with a diameter of 2.5 cm each, but features various masses, including a hollow steel ball, solid steel ball, plastic ball and aluminum ball.

Order Information

Spherical Mass Set ME-8968

Launcher Sights

ME-9865



Purchase this 5 pack of aiming sights as a replacement for the Short-Range or Long-Range Projectile Launchers.

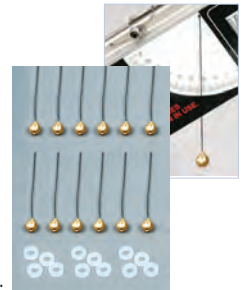
Order Information

Launcher Sights ME-9865

Launcher Plumb Bobs (12 pack)

ME-9868A

This kit includes 12 brass plumb bobs and 12 washers to replace lost or broken parts from any of PASCO's projectile launchers.



Order Information

Launcher Plumb Bobs (12 pack) ME-9868A

Large C Clamp (6 pack)

SE-7285

These rugged clamps are perfect for attaching a variety of objects to a table. Size 10 cm (4 inch).



Order Information

Large C Clamp (6 pack) SE-7285

Plumb Bobs (10 pack)

SE-8728



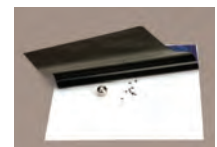
Order Information

Plumb Bobs (10 pack) SE-8728

Carbon Paper (100 sheets)

SE-8693

Carbon paper is ideal for marking the position of an object as it strikes the floor or other surface.



Order Information

Carbon Paper (100 sheets) SE-8693

Ballistics

Ballistic Pendulum

ME-6830

- ▶ Extremely accurate: $\pm 2.5\%$ of predicted values
- ▶ Both elastic and inelastic experiments
- ▶ Projectile launcher experiments
- ▶ Now includes ME-6800 bracket!

This classic physics 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.

How It Works

A projectile is fired into a pendulum, causing it to rise.

Using the projectile mass, the pendulum mass, and the rise in pendulum height, students can calculate the gravitational potential energy of the system.

Since the potential energy is equal to the pendulum's kinetic energy at the lowest point, students can calculate the speed of the pendulum at impact.

Applying the Law of Conservation of Momentum, the projectile's speed is easily calculated.

An additional mounting bracket is included to perform the full range of projectile launcher experiments.



Already own a PASCO Projectile Launcher?

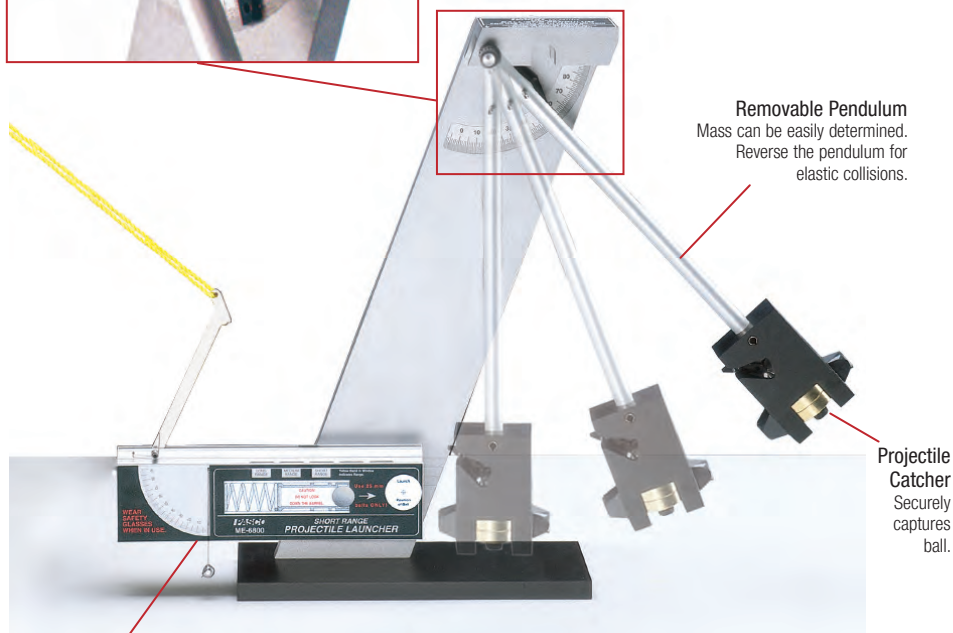
The base and pendulum assembly can be purchased separately.

See Ballistic Pendulum (No Launcher) in the order block for more information.



Unique Angle Measurement Design

Easily measures pendulum angle to 0.5° .
Low friction gives repeatable results.



Projectile Launcher

Durable with three repeatable launch settings.

Removable Pendulum

Mass can be easily determined.
Reverse the pendulum for elastic collisions.

Projectile Catcher
Securely captures ball.



Add Masses

Two 50 g masses (included) can be added to change the pendulum mass and rotational inertia.

Features:

- ▶ **Repeatable:** The three velocity settings on the Projectile Launcher produce consistent velocities.
- ▶ **Accurate:** The $0-80^\circ$ angle measurement scale resolves to 0.5° , leading to experimental results within 2.5% of predicted values.
- ▶ **Removable Pendulum:** Remove the pendulum to determine its mass and center of mass, let it swing freely for rotational inertia calculations, or mount it backwards for elastic collision experiments.
- ▶ **Ball and Pendulum Masses:** This set includes two, 50 g pendulum masses, as well as two steel and two plastic balls.
- ▶ **Projectile Launcher:** Mount the Projectile Launcher on the other side of the base to give students access to its accessories.
- ▶ **Unique Angle Measurement:** The PASCO Ballistic Pendulum pushes a low friction, low mass pointer to the highest point. It remains there, permitting an accurate measurement.

Includes:

- Ballistic Pendulum (without launcher)
- Projectile Launcher
- Projectile Launcher Base
- 2.5 cm Plastic Balls (2)
- 2.5 cm Steel Balls (2)
- Masses (2)
- 2-D Collision Accessory
- Safety Glasses (2)
- Operations and Experiment Manual



Order Information

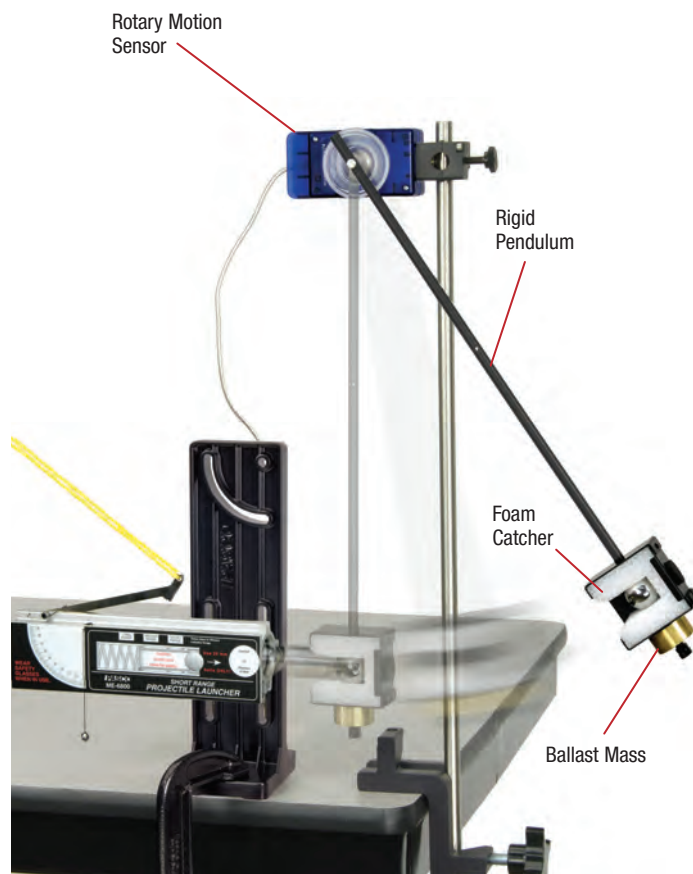
Ballistic Pendulum	ME-6830	
Ballistic Pendulum (without launcher).....	ME-6831	
Recommended:		
Spherical Mass Set	ME-8968	p. 141
Shoot-the-Target	ME-6853	p. 139
Time-of-Flight Accessory	ME-6810A	p. 139
Large C Clamp (6 pack)	SE-7285	p. 141

Ballistic Pendulum Accessory

ME-9892

- Accessory to the Rotary Motion Sensor
- Designed for use with Projectile Launcher (ME-6800) on page 136.
- Low cost

This Ballistic Pendulum Accessory uses a Rotary Motion Sensor to measure the speed of the catcher immediately after the collision, as well as the maximum height to which the pendulum swings. The Rotary Motion Sensor can also be used to measure the rotational inertia of the pendulum for a detailed study of the collision using conservation of angular momentum.



Includes:

- Pendulum Arm with Catcher
- Ballast Mass
- Steel Ball

Order Information

Ballistic Pendulum Accessory.....	ME-9892	
Recommended:		
Projectile Launcher	ME-6800	p. 136
PASPORT Rotary Motion Sensor	PS-2120A	p. 35

Ballistic Pendulum Kit

ME-1263



Perform These Experiments:

- Inelastic Collisions
- Ballistic Pendulum
- Conservation of Momentum and Energy
- Projectile Motion

This easily-assembled ballistic pendulum consists of a Mini Launcher and Mini Ballistic Pendulum Accessory mounted on a Rotary Motion Sensor. The complete motion of the swing of the pendulum can be graphed.

Perform the conventional ballistic pendulum experiment in which the muzzle velocity of the ball is determined using the maximum height to which the pendulum swings.

Examine the difference between a completely inelastic collision (the ball is caught in the pendulum) to a partially inelastic collision (the ball bounces off the back side of the pendulum).

Verify that the angular momentum of the ball (as measured about the pivot point) is equal to the angular momentum of the ball and pendulum immediately after the ball is caught.



Includes:

- Mini Launcher ME-6825B
- Mini Ballistic Pendulum Accessory ME-6829
- Wireless Rotary Motion Sensor PS-3220
- Wireless Smart Gate PS-3225
- Photogate Mounting Bracket ME-6821A
- Stainless Steel Rod, 60 cm Threaded ME-8977
- Aluminum Table Clamp ME-8995
- Rod Clamp for Rotary Motion Sensor ME-8945

Order Information

Ballistic Pendulum Kit	ME-1263
Also Available Separately:	
Mini Ballistic Pendulum Accessory	ME-6829

Statics

Pulley Demonstration System

SE-8685

- Demonstrate the mechanical advantage of single or combination pulleys
- Complete stand-alone pulley apparatus
- Simple setup

Features:

- **Stable Base:** Easily attach two threaded 81 cm rods to the sturdy base. An eye-hook and capstan are included to demonstrate an entire pulley system.
- **Comprehensive:** Contains everything needed to effectively display the usefulness of pulleys, including slotted masses and mass hangers.
- **Several Pulley Types:** Reveal the benefits of single pulleys, tandem pulleys, quadruple pulleys and even the 4-step pulley. Combine several of them for an efficient pulley system.



Set up a double pulley and a single pulley, each with a 200 g mass. Simultaneously pull the string of each from the same vertical height down to the base. Observe that the mass of the single pulley moves twice as high as the double pulley with twice the force.



Includes:

- 20 cm x 81 cm base with eye-hook and capstan
- Threaded 81 cm rods (2)
- Clamps (2)
- Horizontal rod
- Hook collars (8)
- 90° clamp
- Single pulleys (2)
- Triple-tandem pulleys (2)
- Quadruple pulleys (2)
- Four-step pulley
- Slotted masses (13)
- Mass hangers (6)



Order Information

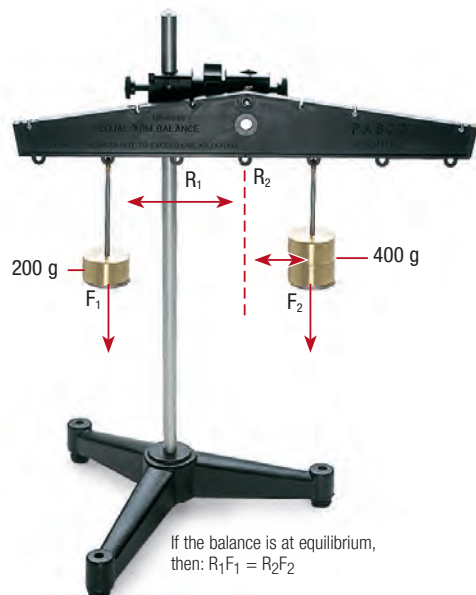
Pulley Demonstration SystemSE-8685

Equal Arm Balance

ME-8949



The Equal Arm Balance was specially designed to simplify the study of torques. This balance has a ball-bearing pivot.



If the balance is at equilibrium, then: $R_1F_1 = R_2F_2$

With 200 g and 400 g masses placed as shown above, the balance remains in equilibrium.

Specifications:

Total Length: 34 cm

Maximum Weight Exerted on Balance Arm: 1 kg or 10 N



Includes:

- Balance Arm with Ball-Bearing Pivot

Order Information

Equal Arm Balance..... ME-8949

Required:

Mass and Hanger Set..... ME-8979 p. 215

Super Pulley Force Table

ME-9447B

- High accuracy
- Easy, compact storage
- Inexpensive!

Adjustable height

The swivel feature of the pulleys can virtually eliminate parallax for more precise angle measurements.

Dual Ball Bearings
For ultra-low friction.

Built-in Scale
Measure angles
quickly and
accurately.

String Tie

String Tie is captured to make setup of hanging masses easy, but it freely floats over bulls-eye pattern to clearly show even small changes in equilibrium.

Strings connect to center of
String Tie for accurate results.

Compact, Easy Storage

Mass and Hanger
(sold separately)

Change the mass by
1/2 gram or an angle
by 1/2 degree and see
an immediate change in
the equilibrium.

Improved Leg Storage

The screw-in legs snap under the table for easy storage.

Improved Stacking

Stacked tables are keyed together to eliminate slipping. Now you can store all your Force Tables in one convenient stack!

Stacking tab keys into
recess in table-top

Includes:

- 25 cm diameter table with detachable legs
- Adjustable Super Pulleys with clamps (3)
- Spool of thread

Mass and Hanger Set is sold separately.

Order Information

Super Pulley Force Table..... ME-9447B

Required:

Mass and Hanger Set..... ME-8979 p. 215

Additional Pulleys:

Super Pulley with Clamp..... ME-9448B p. 149

Statics

Tension Protractor

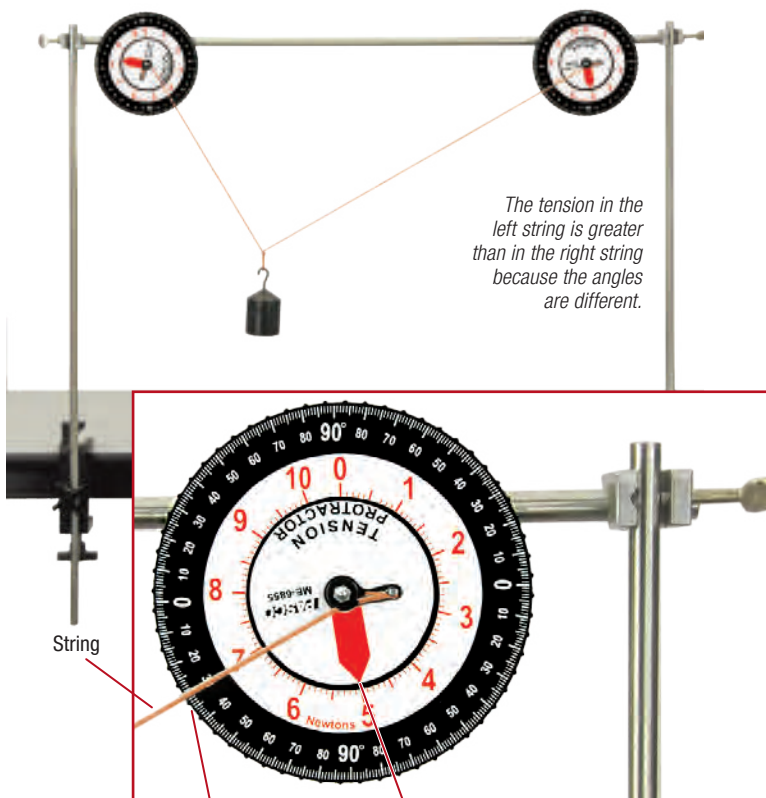
ME-6855

- Measure tension and angle with one device
- Large scale for viewing demonstrations
- Zero-adjust for torsion spring scale
- Built-in rod clamp

The Tension Protractor is a spring scale and a protractor integrated into one device. Perfect for static equilibrium experiments, the rotary dial indicates the tension in the string and the angle is read where the string passes over the degree scale on the outer ring. Since the Tension Protractor is supported on a rod, it has an advantage over other spring scales that tend to weigh down the string, changing the angle.

The string is wrapped once around a small pulley that is spring-loaded. The torsion spring scale is carefully calibrated at the factory and can be zeroed by the user using the thumb screw on the back. The red arrow that indicates tension is color-coded to match the Newton scale.

Even if the mounting rod is not plumb, the Tension Protractor's degree scale can be adjusted to read 90 degrees vertically by rotating the outer ring until the string with a hanging mass aligns with 90 degrees.



Zeroing Ring for Angle Scale

Rod Clamp mounts on either a vertical or horizontal rod.

Zeroing Thumb Screw for Force Scale

30° angle reading

Arrow indicates tension reading (5.0 N)

Specifications:

Force Range: 0 N to 10 N

Force Accuracy: $\pm 4\%$ of reading

Smallest Force Division: 0.1 N

Angle Range: $\pm 90^\circ$

Smallest Angle Division: 1°

Diameter: 15 cm

Includes:

- One Tension Protractor



A 50 gram mass hangs vertically from the Tension Protractor. The tension reads 0.5 N as expected and the outer degree scale is dialed to align the 90° mark with the string. This compensates for unlevel tables or bent rods.

Order Information

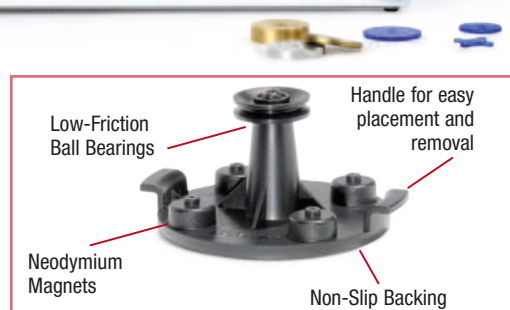
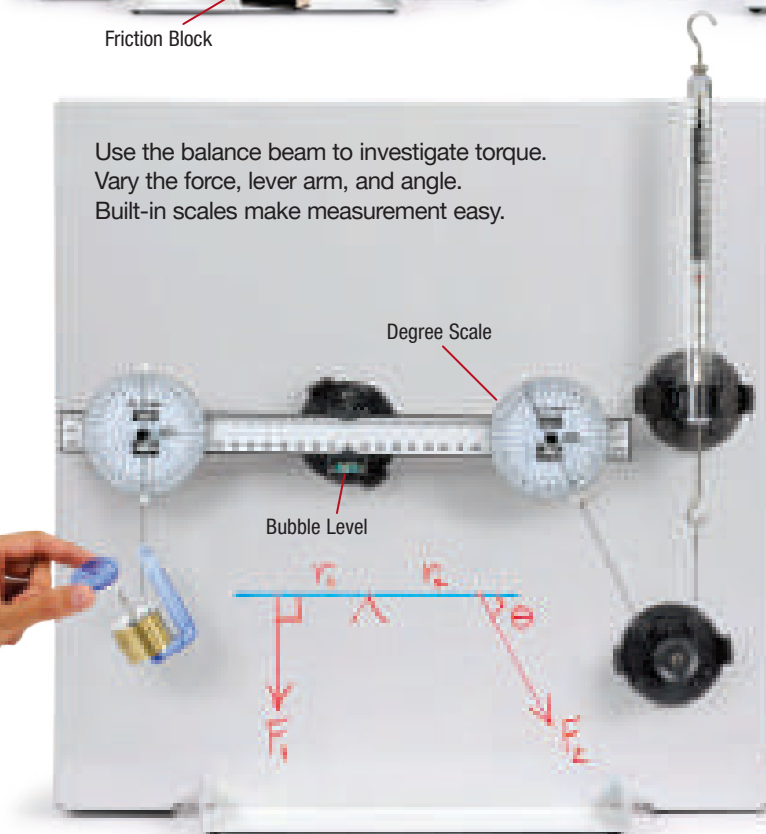
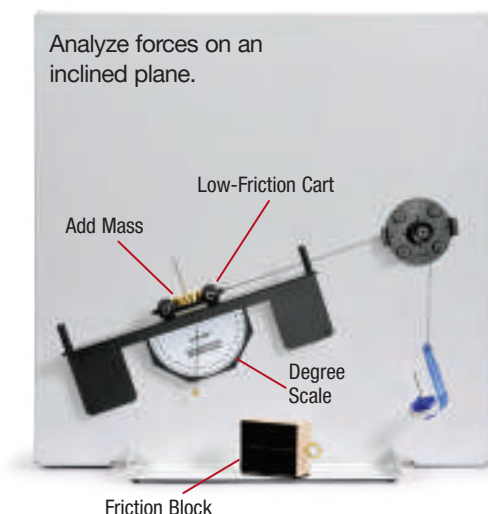
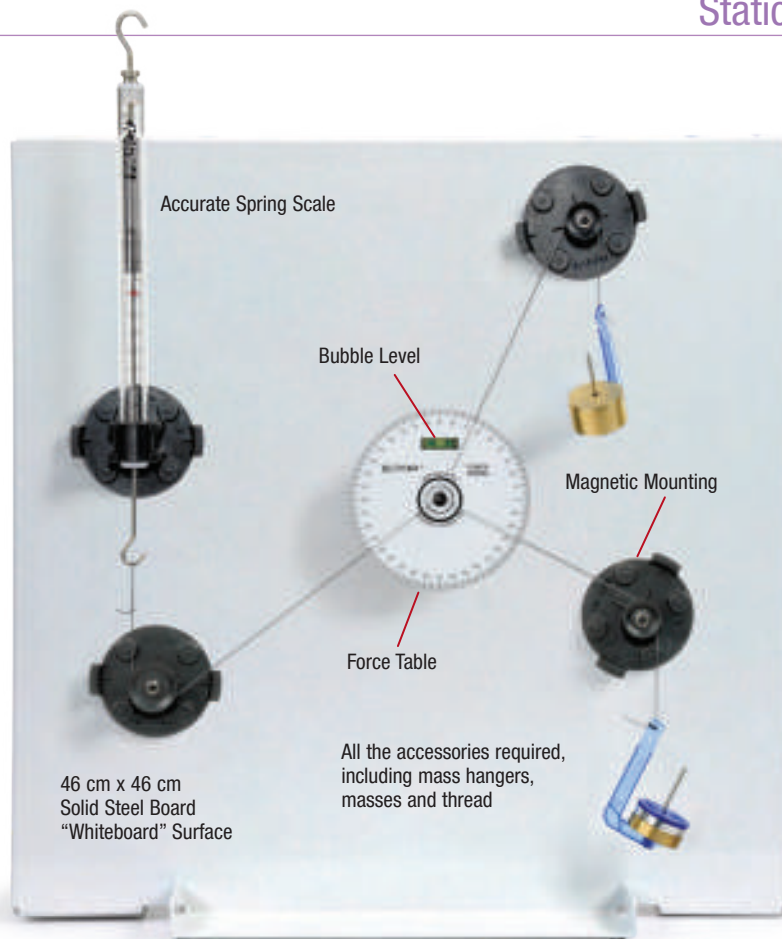
Tension Protractor.....	ME-6855	
Recommended:		
Large Table Clamp	ME-9472	p. 207
90 cm Stainless Steel Rod	ME-8738	p. 204
Multi-Clamp.....	ME-9507	p. 206
Hooked Mass Set.....	SE-8759	p. 215

Statics System

ME-9502

- Everything required for 15 experiments
- Comprehensive — from vector addition to simple machines
- Easy Setup — magnetic mounting

The Statics System is a versatile lab system designed for demonstrating the basic concepts of vector forces, torques, center of mass, simple machines, and more. When combined with the ME-9503 Statics Board (sold separately), the Statics System doubles in width, making it ideal for demonstrations.



Easy Storage

Store magnetic components on back of experiment board.

Includes:

- Experiment Board
- Components
- Mass Set
- Comprehensive Manual with 16 Copy-Ready Experiments



Order Information

Statics System.....	ME-9502
Additional Equipment:	
Statics Board	ME-9503
Spring Scale	ME-9824A
Statics Spares Package	ME-9504

Meter Stick Torque

Meter Stick Torque Set

ME-7033

Create an improved version of the meter stick balance by mounting the Pivot on a rod stand and using an aluminum meter stick. The Meter Stick Clamp has a built-in bubble level to indicate when the meter stick is level.

The Meter Stick Clamp fits onto either the provided dual-ball bearing Pivot or a Rotary Motion Sensor. It has two mounting points: One is centered on the center of the meter stick for rotation and pendulum experiments and the other is offset so the center of mass of the meter stick is below the pivot point for stability in meter stick torque experiments.

The mass hangers have a mass of 10 grams each, which makes it easy to add to the hanging mass. The Mass Hangers have a degree scale so the angle of the applied force can be read. The Mass Hangers can be used in two ways:

- As a mass hanger in a meter stick torque experiment with the masses hanging from it
- Upside-down, as an anchor point for a suspension string at any angle in a statics experiment.

Features:

- ▶ Dual ball bearings in Pivot
- ▶ Mount at any height on any rod stand
- ▶ Mass hangers (10 g) have built-in angle indicators
- ▶ Built-in bubble level on Pivot meter stick clamp

Specifications:

Aluminum Meter Stick Dimensions:

6.95 mm x 28.0 mm x 1.0 m

Aluminum Meter Stick: Approximate mass 150 g

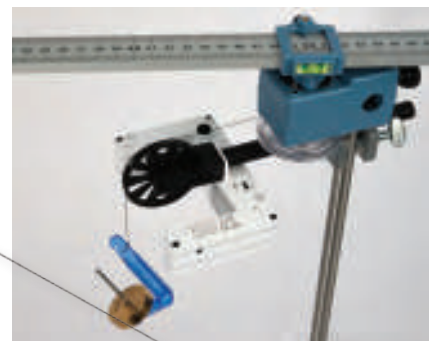
Pivot Slotted Shaft: 1/4-inch (6.35 mm) diameter, 16 mm long out both sides

Mass of Hangers: 10 g

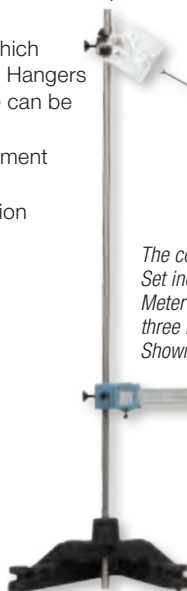


Perform These Experiments:

- ▶ Meter Stick Torque
- ▶ Statics – Suspended Boom
- ▶ Physical Pendulum



The complete Meter Stick Torque Set includes the Pivot, Aluminum Meter Stick, Meter Stick Clamp, and three Mass Hangers. Shown in use with Wireless Force Sensor.



Includes:

- Pivot: ME-7034
- Meter Stick Torque Mass Hanger Set: ME-7035
- Aluminum Meter Stick

Order Information

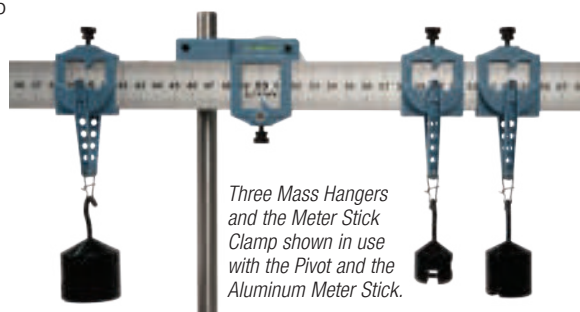
Meter Stick Torque Set..... ME-7033

Required:

Rod Stand..... p. 204

Meter Stick Torque Mass Hanger Set

ME-7035



Three Mass Hangers and the Meter Stick Clamp shown in use with the Pivot and the Aluminum Meter Stick.

Replacement set of three Mass Hangers and one Meter Stick Clamp for doing meter stick torque experiments.

The meter stick clamp fits onto either a Pivot (ME-7034) or a Rotary Motion Sensor.

Includes:

- Meter Stick Clamp
- Mass Hangers (3)



Order Information

Meter Stick Torque Mass Hanger Set ME-7035

Required:

Aluminum Meter Sticks (6 pack) ME-7032 p. 208

Pivot

ME-7034

The Pivot is a general purpose rotation device that allows you to mount it on a rod stand to perform rotation experiments in the horizontal or vertical planes.

Perform These Experiments:

- ▶ Meter Stick Torque
- ▶ Rotational Inertia
- ▶ Physical Pendulum
- ▶ Centripetal Acceleration

Includes:

- Pivot
- 3-step Pulley



This Pivot can be used as a fulcrum for meter stick torque experiments or as a rotational platform for rotational inertia experiments.

Order Information

Pivot ME-7034

Super Pulley

ME-9450A

- ▶ 20 N max load
- ▶ Nearly frictionless
- ▶ Durable



The PASCO Super Pulley is the standard in physics labs. Its low-friction design produces excellent results. The precision spacing of the 10 spokes makes it ideal for photogate monitoring with PASCO's computer interfaces and photogate systems.

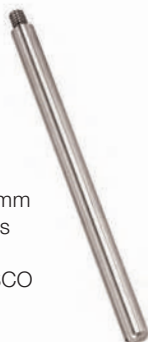
Order Information

Super Pulley ME-9450A

Pulley Mounting Rod

SA-9242

This 14 cm long stainless steel mounting rod is 9.5 mm (3/8 in.) in diameter and fits most standard laboratory clamps, including the PASCO Universal Clamp. It has a standard 1/4"-20 thread.



Order Information

Pulley Mounting Rod SA-9242

Wireless Smart Pulley

PS-3704

The Wireless Smart Pulley attaches directly to the Wireless Smart Gate, providing a simple, low-friction system to measure position, velocity and acceleration.

Remove the pulley to use the photogate for standard photogate experiments.



Includes:

- Wireless Smart Gate (1) PS-3225
- Super Pulley (1) ME-9450A
- Super Pulley Rod (1)

Order Information

Wireless Smart Pulley PS-3704

Super Pulley with Mounting Rod

ME-9499

This Super Pulley is mounted on a rigid plastic mounting rod (12.7 mm diameter, 14 cm long) and fits most standard laboratory clamps.



Order Information

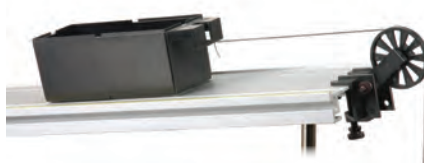
Super Pulley With Mounting Rod ME-9499

Super Pulley with Clamp

ME-9448B



Upgrade your force table and inclined plane experiments. The Super Pulley with its integral clamp makes setup and alignment easy. The pulley height is fully adjustable, so you can skim the top of a force table for parallax-free readings. Yet you can keep the force parallel to the track on an inclined plane, as shown in the photo below. Fits tables up to 2.0 cm (13/16 in.) thick.



Order Information

Super Pulley with Clamp ME-9448B

Mounting Rods (10 pack)

ME-9483

These rigid plastic pulley handles (14 cm long, 1.27 mm diameter) screw into a Super Pulley.



Order Information

Mounting Rods (10 pack) ME-9483

Photogate & Pulley System

ME-6838A

The Super Pulley attaches directly to a Photogate Head, providing a simple, low-friction system to measure position, velocity and acceleration. Additionally, with the pulley removed, the photogate can be used to perform standard photogate experiments.



Order Information

Photogate & Pulley System ME-6838A

Atwood's Machine

SA-9241



Two Super Pulleys mounted on a 6.4 cm long rod produce a classic, low-friction introduction to Newton's Second Law. The instruction sheet fully describes both the experiment and the theory.



Includes:

- 2 Pulleys
- 1 Connecting Rod

Order Information

Atwood's Machine SA-9241

Human Applications

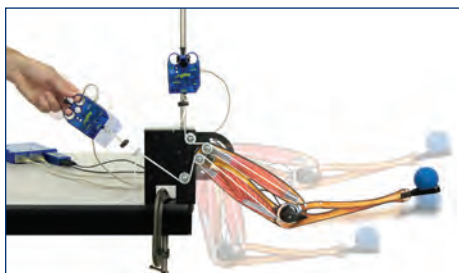
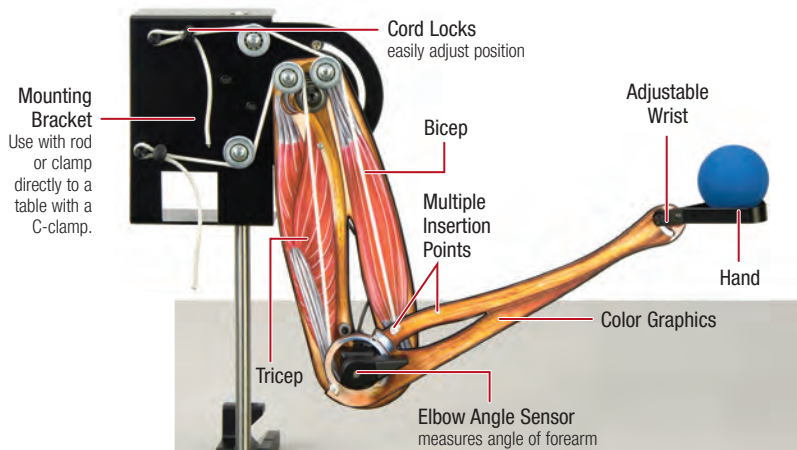
Human Arm Model

PS-2611

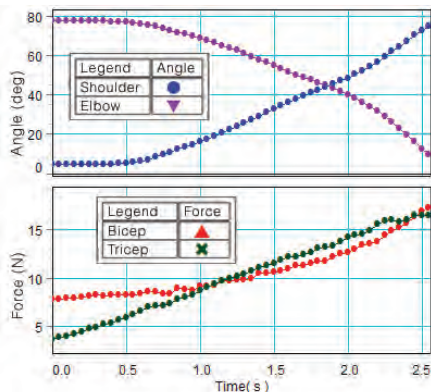
- ▶ Working Model of the Human Arm
- ▶ Associate Triceps/Biceps Muscle Action with Arm Motion
- ▶ Measure Torque Resulting from Lifting Weights
- ▶ Actually Throws a Ball

The Human Arm Model simulates the muscles and motion of an actual human arm. To activate the arm motion, students pull on the cord with a Force Sensor. Changes in position are measured at the shoulder and elbow using the two built-in potentiometers plugged into one Angle Sensor (PS-2139), included with PS-2611. From this information, the torque applied when lifting an object can be determined. Also, students can evaluate the work done by the arm in throwing a ball and the resulting kinetic energy delivered to the ball.

The Arm can perform many types of motion such as extending and lifting an object, curling, or throwing a ball overhand. Different arm muscles are activated depending on which pulleys are selected. Static force measurements can also be made to see how the muscle tension changes at various arm positions.

**Extension**

As the tricep muscle is pulled with a Force Sensor, another fixed Force Sensor records the tension in the bicep muscle cord.

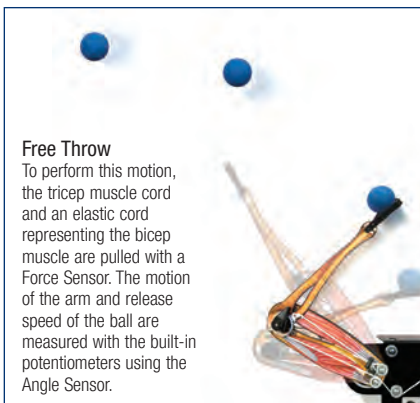
**Angles and Forces During Extension**

The upper graph shows the angles of the elbow (violet trace) and the shoulder (blue) as the arm is extended as shown in the picture above. Shown in the lower graph, the bicep tension (red) has little change at first and then rises sharply as the arm reaches out, while the tricep tension (green) rises steadily.

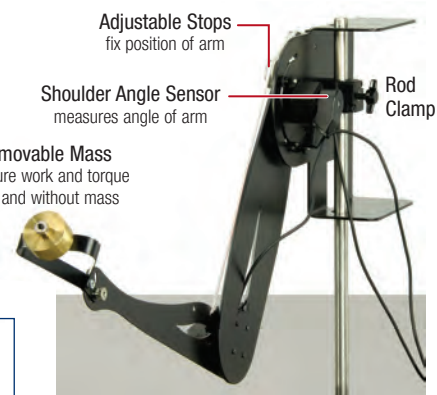
Developed in cooperation with Nancy Beverly, Associate Professor of Physics at Mercy College, Dobbs Ferry, New York.

**Curl**

As the bicep muscle cord is pulled a short distance, the end of the arm moves through a very large distance, showing the mechanical advantage of the arm. The load at the end of the arm can be varied.

**Free Throw**

To perform this motion, the tricep muscle cord and an elastic cord representing the bicep muscle are pulled with a Force Sensor. The motion of the arm and release speed of the ball are measured with the built-in potentiometers using the Angle Sensor.

**Includes:**

- Arm
- Angle Sensor
- Removable Mass
- Cord & Cord Locks
- Mounting Bracket with Rod
- Force Sensor Mounting Rod
- Rubber Ball

**Order Information**

Human Arm ModelPS-2611
 Human Arm Model
 Without SensorsME-6807A

Required:

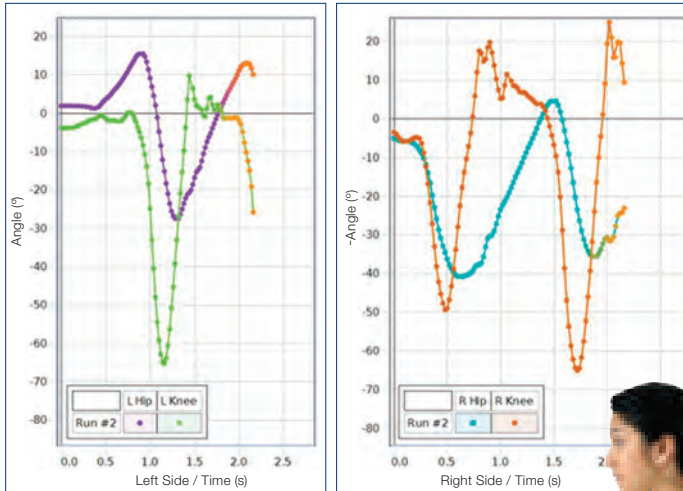
"C" Clamp or Large Table Clamp p. 207
 PASPORT
 Force SensorPS-2104 p. 36
 850 Universal
 InterfaceUI-5000 p. 20

Goniometer

PS-2137

- ▶ Accurately measures joint movements
- ▶ Flexible mounting options for hip, knee, and elbow

The SPARKlink Air Interface is used here with two Angle Sensors, part of the PS-2137 Goniometer System. The data is sent via Bluetooth® to a desktop computer and displayed live with the video being recorded by a web cam.



Data shows position of both left and right knee and hip joints during walking.

Capture data remotely!

The SPARKlink Air Interface records the sensor data and sends it to the computer via Bluetooth.



Goniometer Probes

The probes are fastened in place using the blue Velcro® straps and can be positioned to measure the motion of the knee, hip, or elbow.

Developed in cooperation with Nancy Beverly, Associate Professor of Physics at Mercy College, Dobbs Ferry, New York.

Specifications:

Range: 0 to 340°

Accuracy: ±1° (calibrated), ±3° (uncalibrated)

Resolution: 0.1°

Maximum Sample Rate: 500 Hz

Order Information

Goniometer Sensor	PS-2137	
Recommended:		
SPARKlink Air	PS-2011	p. 50
Additional Goniometer Straps	PS-2547	
Additional Goniometer Probe	PS-2138	

Includes:

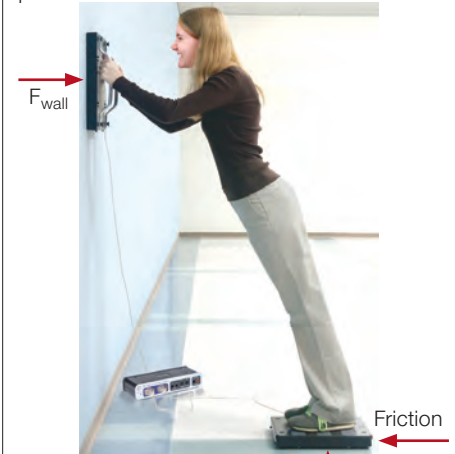
- Goniometer Probe
- Angle Sensor
- Velcro Straps



Forces on the Human Body

- ▶ Measure forces on human body
- ▶ 1-axis and 2-axis force platforms
- ▶ Precise and fast

Explore the forces exerted on the human body in everyday situations, sports, and large-scale physics experiments. The force platforms are designed to measure large forces, such as the weight of a person.



By standing on a 2-Axis Force Platform while pushing against the wall with a 1-Axis Force Platform, a real-life statics problem can be analyzed.



Confirm Newton's third law by pushing on a Force Platform using two sets of handles (available separately). Handles bolt onto the Force Platform (1-axis or 2-axis) and can be mounted on one or both sides.

Developed in cooperation with Nancy Beverly, Associate Professor of Physics at Mercy College, Dobbs Ferry, New York.

Order Information

PASPORT 2-Axis Force Platform	PS-2142	p. 37
PASPORT Force Platform	PS-2141	p. 37
Handle Set, Force Platform	PS-2548	p. 37

Motorized Structures

Motorized Crane

ME-7030

The Motorized Crane is made using PASCO Structures and is controlled and powered by the `//control.Node`. Students program the controller to run the stepper motor and servo motors using Blockly coding embedded in PASCO Capstone or SPARKvue software.

The crane picks up objects with an electromagnet which is also controlled and powered by the `//control.Node`. Students can vary the duty cycle to vary the power of the electromagnet to explore the minimum power required to pick up different objects. Steel washers are included with stickers to stick to non-ferrous objects such as paper cups so the electromagnet can pick up a variety of objects.

The crane includes three sets of gears to explore the effect of gear ratios (1:1, 2:1, 4:1) on speed and lifting capability.

Activities:

- ▶ Build the Motorized Crane
- ▶ Introduction to Stepper and Servo Motors
- ▶ Position Boom Angle and Electromagnet height to reach a position
- ▶ Pick up a ball and drop it into a cup on a different level
- ▶ Effect of Gear Ratios on Speed
- ▶ Effect of Duty Cycle on the Load the Electromagnet Can Lift
- ▶ Effect of Spool Diameter

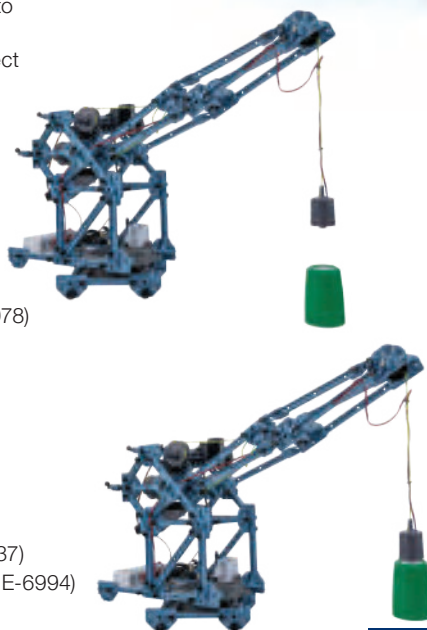
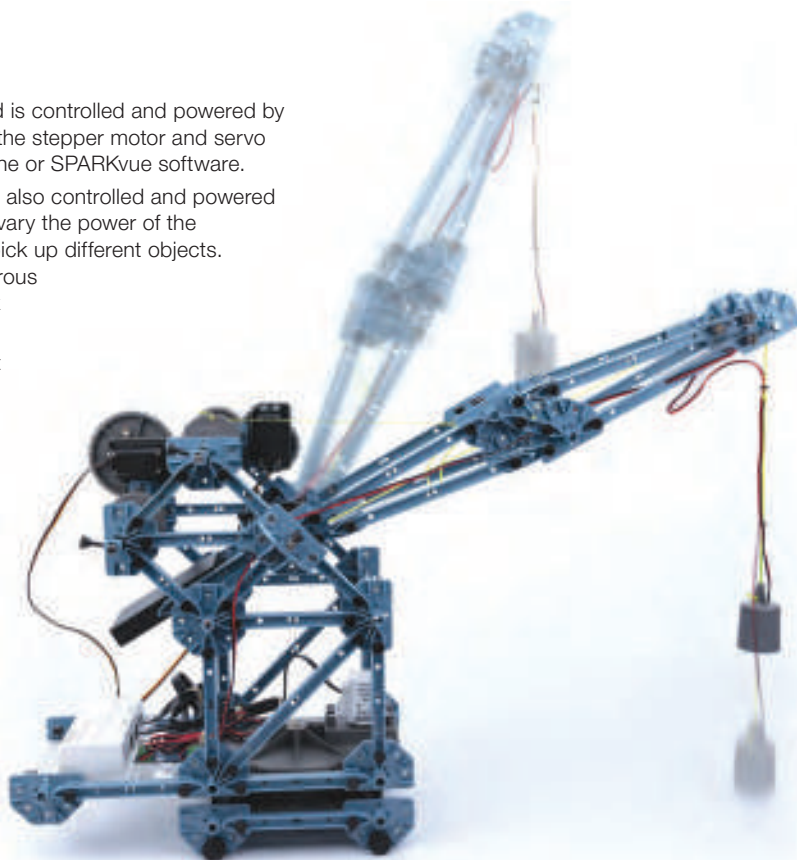
Further Exploration:

- ▶ Add a Wireless Light Sensor to enable the Crane to sort colored objects.
- ▶ Add a Wireless Current Sensor to the Electromagnet to see the effect when an object is picked up.
- ▶ Use the Crane to transfer a cup to the Robot Car.
- ▶ Add a Wireless Load Cell to detect when an object is lifted.

See page 88 for more information about the `//control.node`.

Includes:

- `//control.Node` (PS-3232)
- Low Speed Stepper Motor (PS-2978)
- Power Output Module (PS-3324)
- Servo Motor (2) (SE-2975)
- Gear Set (ME-7021)
- Turntable (ME-7024)
- Electromagnet (ME-7027)
- Structures I-Beams (45)
- Structures Connectors (26)
- Structures Counterweight (ME-7037)
- Truss Set Screws (2 sets of 75) (ME-6994)
- Axles (4)
- Small Pulley (2)
- Motor Mount (set of 2) (ME-7020)
- Spool and Bearings (2) (ME-7022)
- `//control.Node` Platform (ME-7042)
- 0.625-inch Steel Ball (2)
- Storage Box



Features:

- ▶ The controller can execute its code via Bluetooth or USB connection to a computer or autonomously via uploaded code.
- ▶ The motors and electromagnet on the crane are powered by the rechargeable battery in the `//control.Node`.
- ▶ The position and speed of the stepper motor and electromagnet can be displayed in the software while the code is executed.
- ▶ The cable spool has two diameters to learn about mechanical advantage.
- ▶ The `//code.Node` accelerometer is used as a joystick to move the crane so the crane can learn the locations of certain positions.
- ▶ Students build the crane and can change the design using additional Structures parts.
- ▶ Any PASCO sensor can be used with the crane to expand its capabilities.

Specifications:

Length of Crane Boom from Pivot Point: 44 cm
Maximum Height of End of Crane Boom: 67 cm
Crane Base: 16 cm x 16 cm

Order Information

Motorized CraneME-7030
 Also Available:
 Motorized Crane without `//control.Node`ME-7040
 Required:
 SPARKvue Softwarepp. 12-13
 OR
 PASCO Capstone Softwarepp. 8-11

Motorized Drawbridge

ME-7028

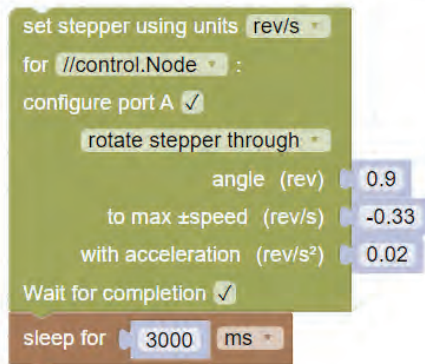
Build this drawbridge from PASCO Structures, add a stepper motor and gears, and write code to raise and lower it. This bridge kit also includes a Wireless Load Cell/Accelerometer to measure forces within the bridge while it moves.

Activities:

- Build the drawbridge.
- Raise and lower the drawbridge.
- Measure forces in top and bottom beams.
- Measure support forces.
- Explore the effect of the counterweight on motor acceleration.
- Explore the effects of different gear ratios.
- Use the load cell as a limit switch.
- Operate the drawbridge in response to a signal.

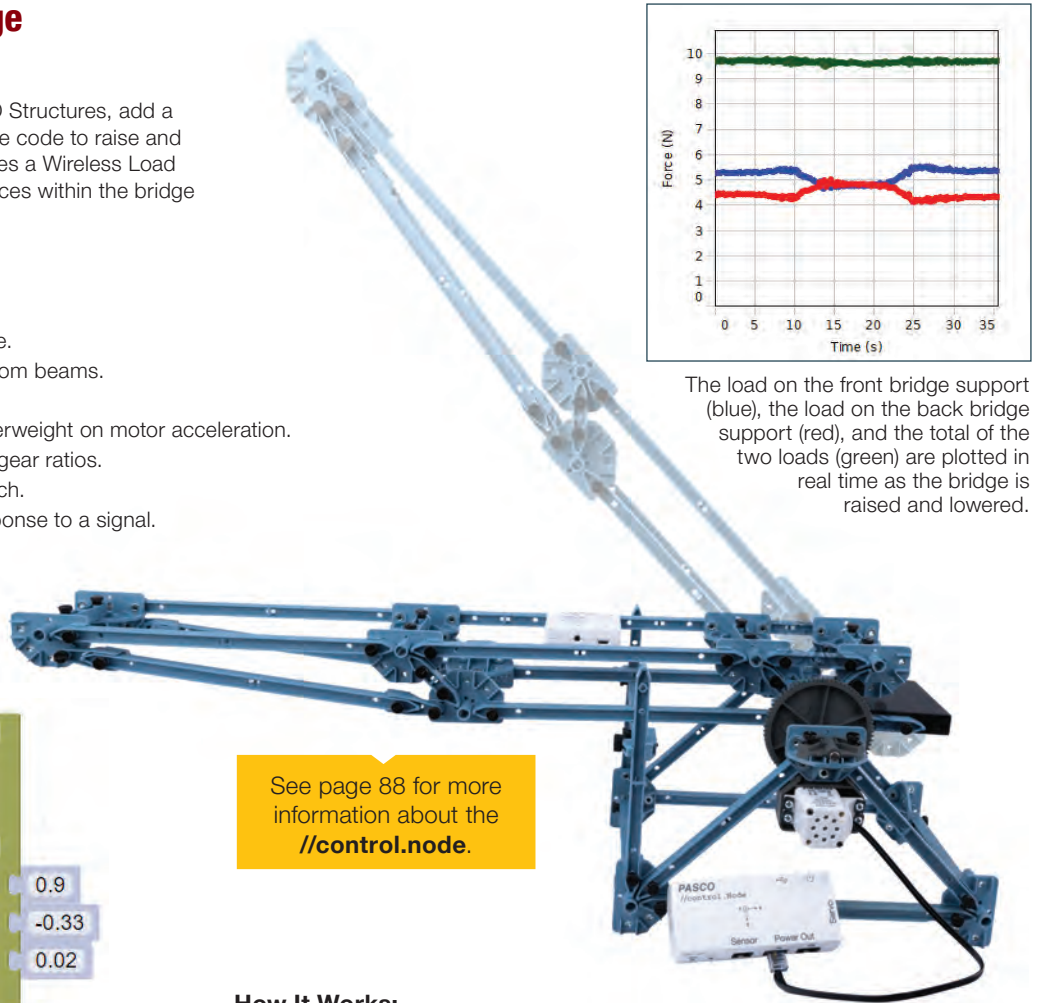


Students write Blockly code to control the drawbridge motion.

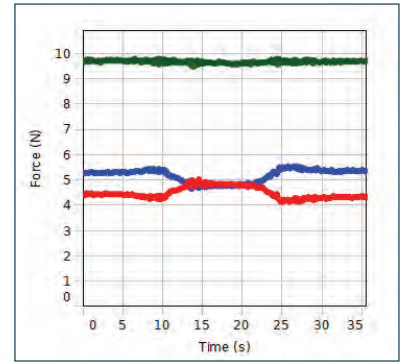


Includes:

- //control.Node (PS-3232)
- Wireless Load Cell and Accelerometer (PS-3216)
- Low Speed Stepper Motor (PS-2978)
- Gear Set (ME-7021)
- Structures Counterweight (ME-7037)
- Structures I-Beams (40)
- Structures Connectors (18)
- Structures 6-32 Screws (100)
- Structures Long Axle (1)
- Motor Mount (1)
- Storage Box



See page 88 for more information about the **//control.node**.



The load on the front bridge support (blue), the load on the back bridge support (red), and the total of the two loads (green) are plotted in real time as the bridge is raised and lowered.

How It Works:

Students build the drawbridge using step-by-step illustrated instructions. Then they use Blockly coding (imbedded in PASCO's Capstone or SPARKvue software) to program the drawbridge to raise and lower.

Three sets of gears allow students to investigate the effects of different gear ratios.

The Load Cell can be added to various places in the bridge to measure loads while the bridge moves. The load is displayed on a graph in real time.

The Load Cell can be used as a limit switch to stop the bridge movement when the bridge arm pushes on the load cell.

The speaker in the //control.Node can be programmed to beep or play music to warn when the bridge is going to move.

The accelerometer in the //control.Node can be used to control the drawbridge movement in response to a change in acceleration, such as simply turning the //control.Node upside-down.

Specifications:

Length of Drawbridge Span: 65 cm

Order Information

Motorized Drawbridge	ME-7028
Also Available:	
Motorized Drawbridge without //control.Node	ME-7038
Required:	
SPARKvue Software	pp. 12-13
OR	
PASCO Capstone Software	pp. 8-11

Motorized Structures

Robot Car

ME-7029

- ▶ Multiple configurations: With and without the gripper, two wheels or three wheels, front-wheel steering or dual back-wheel steering
- ▶ Add other PASCO Structures components to change the Robot Car's design
- ▶ Add other PASCO sensors to expand the bot's capabilities

This versatile robot is constructed out of PASCO Structures components, enabling students to build several different configurations of the Robot Car (front-wheel steering, rear-wheel steering, with and without the gripper).

The Robot Car can navigate through a maze, turn in circles, and pick up objects with its gripper. The detailed instructions step the student through building the Robot Car and learning to program the Robot Car movement using Blockly coding embedded in PASCO Capstone or SPARKvue software.

The Robot Car has a huge advantage over other conventional robot kits. Since the Blockly coding is embedded in PASCO Capstone and SPARKvue software, students can view and record the position and velocity of the BOT stepper motors in a live graph in the software. They can also view output variables from their code in digital displays so they can associate what motion the BOT is performing with sections of their code. This helps them trouble-shoot their code.

Perform These Experiments:

- ▶ Build the Robot Car
- ▶ Move the Bot Forward and Backward
- ▶ Turning the Bot
- ▶ Power Steering of Front Wheel
- ▶ Moving Objects with the Gripper
- ▶ Go to a Spot and Return
- ▶ Navigate a Maze
- ▶ Turn in a Circle
- ▶ Create a Function

Further Exploration:

- ▶ Add a Wireless Motion Sensor to avoid obstacles.
- ▶ Add two Light Sensors to follow a line.
- ▶ Add a //code.Node to steer the Bot.
- ▶ Add a //code.Node for turn signals.
- ▶ Add a Wireless Light Sensor to sort colored objects.

Includes:

- //control.Node (PS-3232)
- High Speed Stepper Motor (2) (PS-2976)
- Servo Motor (2) (SE-2975)
- Structures Gripper (ME-7025)
- Gear Set (ME-7021)
- Caster Wheel (ME-7023)
- Structures Hinge (ME-7026)
- Truss Set Screws (set of 75)
- Structures I-Beams (14)
- Structures Connectors (7)
- Structures Full-Round Connector (2)
- Structures Wheels with Tires (2)
- Structures Medium Axle
- Motor Mount (3) (ME-7020)
- //control.Node Platform (ME-7042)



See page 88 for more information about the **//control.node**.

How It Works:

Students use PASCO Structures in this kit to build the Robot Car.

Stepper motors and servo motors are used to move the BOT and its gripper.

The motors are powered and controlled by the Robot Car's //control.Node.

Students program the bot using Blockly coding embedded in PASCO Capstone or SPARKvue software.

The Robot Car can connect to a computer wirelessly via Bluetooth or code can be uploaded to the Robot Car to run autonomously.



Features:

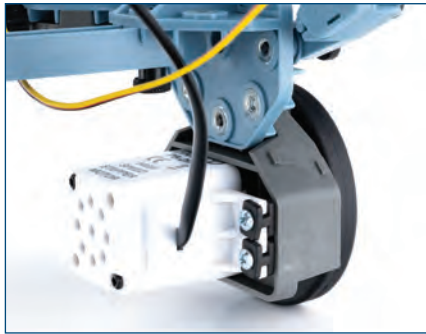
- ▶ **Multiple Configurations:** With and without the gripper, two wheels or three wheels, front-wheel steering or dual back-wheel steering
- ▶ **Expandability:** Add other PASCO Structures components to change the Robot Car's design
- ▶ **Expandability:** Add other PASCO sensors to expand the BOT's capabilities

Order Information

Robot Car	ME-7029
Also Available:	
Robot Car without //control.Node	ME-7039
Required:	
SPARKvue Software	pp. 12-13
OR	
PASCO Capstone Software	pp. 8-11

Motor Mount (set of 2)

ME-7020



Attach PASCO Stepper Motors or regular size servo motors to PASCO Structures using this motor mount.

The included spline shaft adapter fits onto the spline of the motor to create a shaft that fits through a hole in the motor mount. The motor attaches to the motor mount with four screws. The motor mount has the same connection features (pin and screw hole) as the Structures I-beams, so it can be attached to any Structures connector. The Structures Gripper uses the Motor Mount to attach the gripper arms.

Applications:

- Mount motors to power wheels on a car built from PASCO Structures.
- Mount a motor to power a winch on a structure.
- Attach a servo motor to a Structures Gripper to grab objects with an arm built from PASCO Structures.

Specifications:

Shaft Hole Diameter: 6.5 mm

Four 4-40 Threaded Inserts to Attach motor: 10 mm separation on each end; 49 mm separation from end-to-end

Screws: 4-40 1/2-inch long Phillips



Includes:

- Motor Mount plastic housing (2)
- Spline shaft adapter (2)
- 4-40 1/2-inch screws for attaching motors to Motor Mount (8)

Order Information

Motor Mount (set of 2) ME-7020

Gear Set

ME-7021



These three pairs of gears are driven by stepper motors or servo motors to make PASCO Structures move. These three pairs enable three different gear ratios (1:1, 2:1, 4:1) with the same shaft separation, making it easy to change gear ratios.

The gears are secured on the motor shaft or PASCO Structures axles using the included anti-backlash screws.

The 60T and 72T gears have the hole and threaded hole features that allow a Structures I-beam to be attached directly to the gear.

Applications:

- Raise and lower a drawbridge made from PASCO Structures.
- Add motors to operate a crane made from PASCO Structures.
- Steer the front wheel of a 3-wheel robotic car made from PASCO Structures.
- Explore the affect of gear ratios on speed.
- Explore the affect of gear ratios on torque.

Specifications:

Gear Ratio 1:1: Two 45-tooth gears

Gear Ratio 2:1: 60-tooth and 30-tooth gears

Gear Ratio 4:1: 72-tooth and 18-tooth gears

Center-to-Center Spacing of Set of Two Gears: 4.8 cm

Anti-Backlash Screws: 8-32 3/4-inch

Gear Shaft Diameter: 0.25 inch/6.4 mm



Includes:

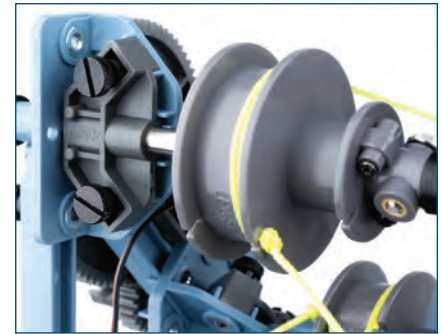
- 18-tooth gear
- 30-tooth gear
- 45-tooth gear (2)
- 60-tooth gear
- 72-tooth gear
- Anti-backlash screws (6)
- Washers for exact spacing (12)

Order Information

Gear Set ME-7021

Spool and Bearings

ME-7022



This two-step spool is used to make a powered winch with PASCO Structures. The spool is secured onto a Structures axle with the include anti-backlash screw. The axle passes through the two included plastic bearings that are screwed to the Structures connectors. These bearings ensure smooth rotation of the axle. String can be wrapped around either step of the spool to explore the difference in speed and torque created by different spool diameters.

Applications:

- Make a winch to raise and lower the electromagnet on a crane.
- Raise and lower the boom on a crane.

Specifications:

Spool Diameters: 1.5-inch (3.8 cm); 0.75-inch (1.9 cm)

Shaft Hole Diameter: Designed for 1/4-inch (6.4 mm) shaft

Anti-Backlash Screw: 6-32 3/4-inch slotted

Length of Bearing Hole: 23 mm



Includes:

- Two-step spool
- Shaft bearing (2)
- Anti-backlash 6-32 screw

Order Information

Spool and Bearings..... ME-7022

Motorized Structures Accessories

Caster Wheel

ME-7023

This caster wheel is part of the Motorized Robot Car, but it also can be purchased separately to add to your own PASCO Structures designs.

Specifications:

Wheel Diameter: 6.3 cm

Shaft Dimensions:

Diameter 1/4-inch (0.64 cm);
Length 4-inches (10 cm)

Includes:

- Caster wheel with shaft



Order Information

Caster Wheel ME-7023

Axle Bearings (set of 6)

ME-7043



Use two of these Axle Bearings to provide a bearing surface for PASCO Structures axles. The Axle Bearings ensure smooth rotation of the axle and have features that match the Structures connectors so the axle can be screwed into the connector.

Specifications:

Shaft Hole Diameter: Designed for 1/4-inch (6.4 mm) shaft

Length of Bearing Hole: 23 mm



Includes:

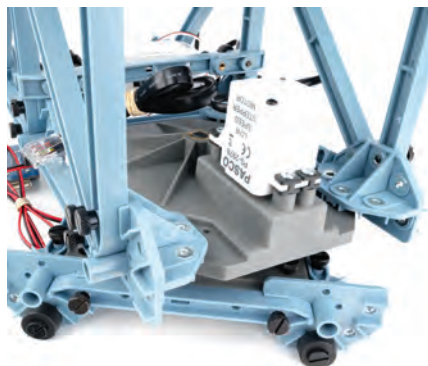
- Axle Bearings (6)

Order Information

Axle Bearings (set of 6) ME-7043

Turntable

ME-7024



This Turntable is designed to rotate cranes made from PASCO Structures. Add a stepper motor to drive the gear mechanism. Connect any structure built with a square composed of #3 I-beams and connectors.

Applications:

- ▶ Rotate a crane built from PASCO Structures.

Specifications:

Base Dimensions: 11.6 cm x 11.6 cm

Gearing: 30-tooth drive gear;
90-tooth base gear

Bracket for Stepper Motor: Four 4-40 threaded inserts; Spline adapter fits 24T spline

Size of Connecting Plate: Designed to connect to a square made with #3 Structures I-Beams and connectors.

Designed for use with:

- ▶ Stepper motors
- ▶ PASCO Structures
- ▶ 30-tooth drive gear
- ▶ 90-tooth base gear
- ▶ Rubber feet
- ▶ 4 through-holes for connecting to Structures using 6-32 screws into Structures connectors



Order Information

Turntable ME-7024

Structures Gripper

ME-7025



Add this Gripper to PASCO Structures to grab objects. Attach a stepper motor or servo motor to the Gripper to drive the gear that opens and closes the gripper arms. The Gripper has the same pin and screw features that attach a Structures I-beam to a connector, making it easy to attach the Gripper to any existing PASCO Structure.

Features:

- ▶ Gripper mounts to PASCO Structures using the same pin and screw features that are used to connect an I-beam
- ▶ Elastic bands add gripping friction
- ▶ The //control.Node can detect the increase in servo current so you can tell when the Gripper has closed on an object.

Specifications:

Gripper Arm Length: 10 cm

Open Angle: 0° to 180°



Includes:

- Gripper arms (2)
- Motor mount
- Elastic bands (20)
- Spline shaft adapter (2)
- Anti-backlash screws (2)
- 4-40 screws to attach a motor (4)
- Structures 6-32 screws to attach the gripper arms to the motor mount (4)

Order Information

Structures Gripper ME-7025

Structures Hinge

ME-7026



Use this hinge with the Structures to make movable joints. The hinge is designed to be used with the PASCO Structures axles. The hinge can be locked into place on the axle with two screws.

The hinge has attachment features for up to three Structures I-Beams.

Applications:

- Add a hinge to the Structures Gripper to be able to raise and lower the Gripper.
- Add hinges to a Structures door.

Specifications:

Hinge Length: 5.8 cm

Axle Hole: Designed for 1/4-inch (6.4 mm) axle

Threaded Holes for Locking Hinge Onto Axle: 6-32

Threaded Holes for Attaching Structures I-Beams: 6-32



Includes:

- Hinge
- Anti-backlash 6-32 screw (2)

Order Information

Structures Hinge ME-7026

Electromagnet

ME-7027

This electromagnet can be attached to a winch on a Structures crane to pick up objects. The electromagnet is powered using a Power Output Module plugged into a //control.Node.

The electromagnet includes steel washers and stickers to attach to an object so the electromagnet can pick up a non-ferrous object such as a paper cup.

Change the power to the electromagnet by changing the duty cycle of the applied 5 volts.

Specifications:

Power Lead Wires: 1.75 m long

Maximum Voltage and Current: 5 V; 0.7 A



Includes:

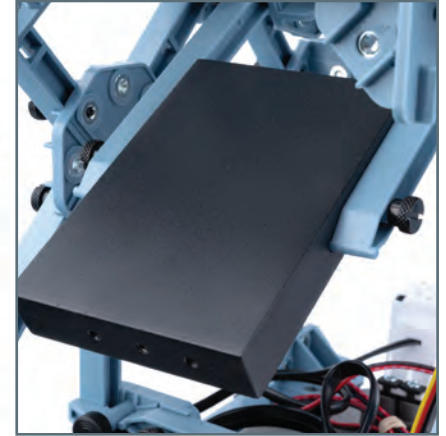
- Electromagnet with lead wires
- Steel fender washers (12)
- Mylar stickers to attach washers to objects (30)
- Roll (70 m) of yellow braided cord
- Small rubber O-rings for attaching wires to cord (10)

Order Information

Electromagnet ME-7027

Structures Counterweight

ME-7037



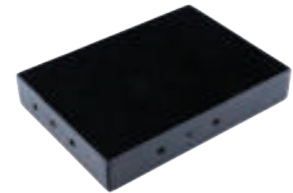
The Counterweight is used to offset the weight of drawbridges and cranes, making them more balanced and requiring less torque to move. Each side has a 6-32 threaded hole and two non-threaded holes that match the same form factor as the Structures I-Beam connectors. This allows the counterweight to be held onto the Structures using I-beams and 6-32 screws.

Specifications:

Mass: 0.8 kg

Steel Dimensions: 6.7 x 9.5 x 1.7 cm

Threaded Holes: 6-32



Order Information

Structures Counterweight ME-7037

//control.Node Platform

ME-7042

This platform secures the //control.Node to Motorized Structures such as the Motorized Crane and the Robot Car. The shape and size of the platform fits into a structures square made from #3 I-beams.

Two sets of slots in the platform allow attachment of the //control.Node in either of two locations. Two screws are included to screw into the inserts on the bottom of the //control.Node.

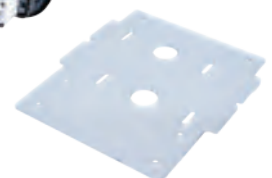
The round holes in the platform act as a guide for the motor cables.



Platform shown in use on the Robot Car.

Includes:

- Acrylic platform
- 6-32 x 1/4-inch Thumb Screws (6)



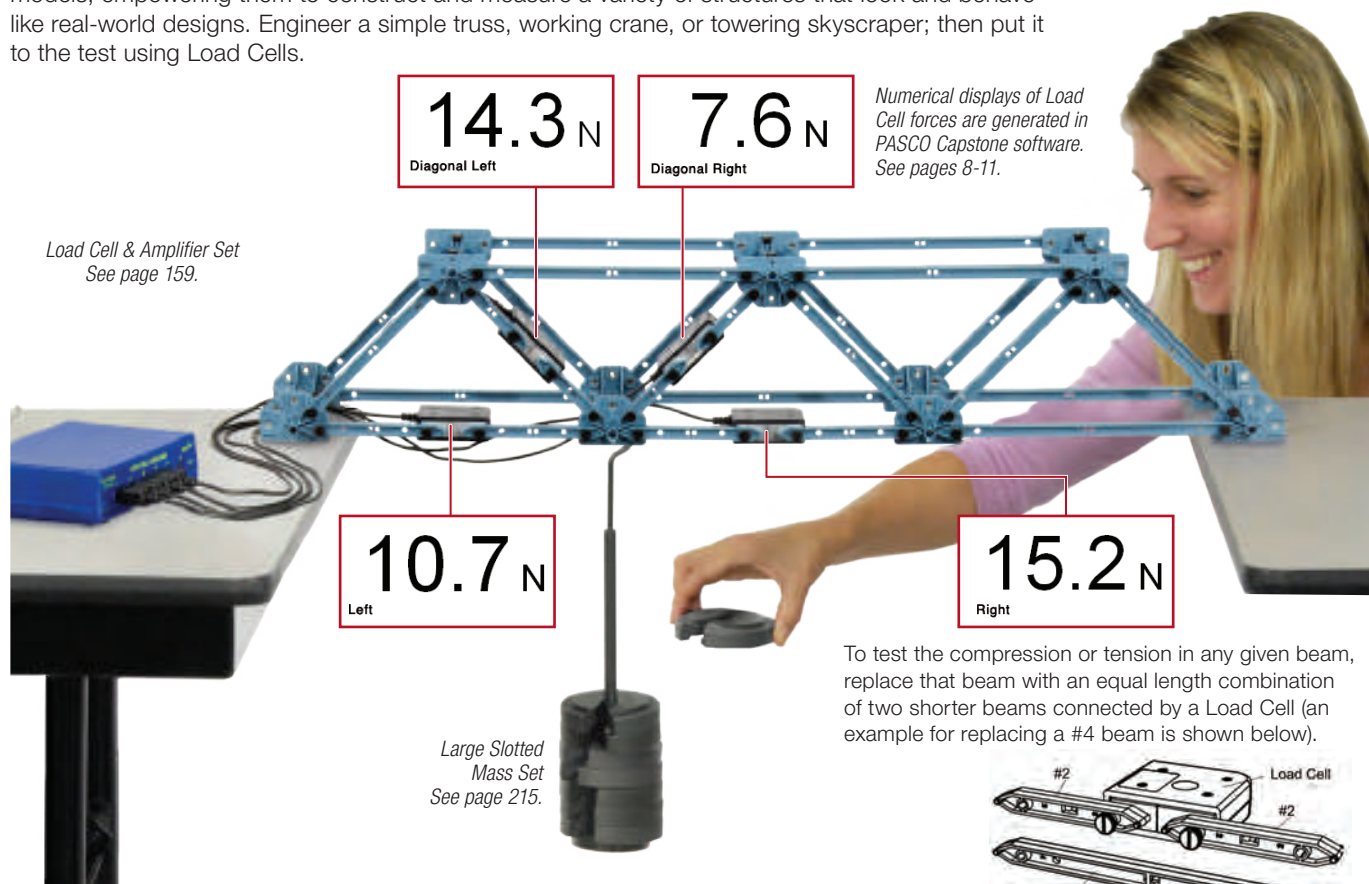
Order Information

//control.Node Platform ME-7042

Structures Systems

Construct and study real-world designs with PASCO's Structures System.

The PASCO Structures System is a one-of-a-kind learning tool designed especially for engineering education. With just a few simple pieces, these sets take students beyond traditional toothpick models, empowering them to construct and measure a variety of structures that look and behave like real-world designs. Engineer a simple truss, working crane, or towering skyscraper; then put it to the test using Load Cells.



Explore the full PASCO Structures System – from trusses to towers to bridges!
Also check out the NEW Motorized Structures.



Materials Tester

See page 172.



Motorized Crane

See page 152.



Human Structures Set

See page 169.



Wired Load Cells and Amplifiers

Load Cell 100 N PS-2200

Load Cell 5 N PS-2201

Load Cells are available in two different ranges: ± 100 N and ± 5 N. These Load Cells are designed to be inserted into structures without changing the length of the member. A Load Cell attached to two shorter beams is equal in length to a longer beam.

These Load Cells require an amplifier (shown below). Load Cells of different capacities can be used with the same amplifier in any combination.

These Load Cells are constructed to reject side-loading, giving a reading of pure compression or tension. The semi-transparent case lets students see the strain gauge and beam inside.

PS-2200 Specifications:

Range: ± 100 N

Accuracy: $\pm 1\%$ (± 1 N)

Resolution: 0.02 N

Safe Overload: ± 150 N

PS-2201 Specifications:

Range: ± 5 N

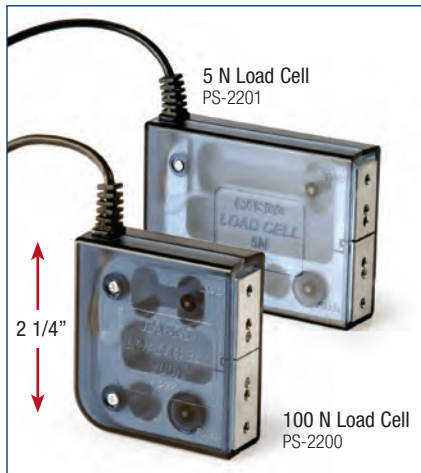
Accuracy: $\pm 1\%$ (± 0.05 N)

Resolution: 0.001 N

Safe Overload: ± 7.5 N

Order Information

100 N Load Cell PS-2200
5 N Load Cell PS-2201



Mix 5 N and 100 N load cells on the same amplifier.

PASPORT Dual Load Cell Amplifier

PS-2205



The Dual Load Cell Amplifier is for applications where only one or two load cells are required, such as measuring the force acting on the top of a roller coaster loop. If you only want to examine the forces in a bridge one at a time, a single load cell can be moved around the bridge. The Amplifier accepts 100 N and 5 N load cells. Each port has a maximum data sample rate of 1000 Hz.

Order Information

PASPORT Dual Load Cell Amplifier PS-2205
Required for use:
PASPORT Interface p. 18
100 N Load Cell PS-2200
5 N Load Cell PS-2201

Also available at a discount:

PASPORT Load Cell and Dual Amplifier Set PS-2206
Set includes:
Dual Load Cell Amplifier (PS-2205)
Load Cell 100 N (PS-2200)
Requires PASPORT Interface (p. 18)



PASPORT Load Cell Amplifier

PS-2198



This Load Cell Amplifier can accommodate up to six load cells and utilizes a single PASCO interface port to connect to a computer's USB port. Students can insert up to six load cells at various points of their structures to extensively analyze their bridges. The Amplifier is compatible with both 5 and 100 N Load Cells, and features a maximum data sampling rate of 500 Hz per port.

Order Information

PASPORT Load Cell Amplifier PS-2198
Required for use:
PASPORT Interface p. 18
100 N Load Cell PS-2200
5 N Load Cell PS-2201

Also available at a discount:

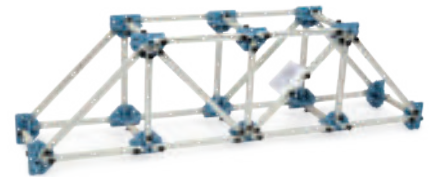
Load Cell and Amplifier Set PS-2199
Set includes:
Load Cell Amplifier (PS-2198)
Load Cell 100 N (PS-2200)
Requires PASPORT Interface (p. 18)



Wireless Load Cell and Accelerometer

PS-3216

- Measures loads in structures
- Built-in 3-axis accelerometer measures bridge vibrations
- No wires to interfere with motion



The Wireless Load Cell and Accelerometer is designed to measure loads in all PASCO Structures Systems. It is particularly useful for measuring vibrations because it includes an accelerometer and has no wires to impede movement.

Specifications:

Force Sensor:

Range: ± 50 N

Resolution: 0.03 N

Accuracy: ± 0.1 N

Maximum Sample Rate: 2 kHz

Accelerometer:

Range: ± 16 g (three-axis)

Maximum Sample Rate: 500 Hz

Connectivity: USB and Bluetooth 5.2

Logging: Yes

Battery Type: Rechargeable LiPo

Order Information

Wireless Load Cell and Accelerometer PS-3216
Shown in use with:
Building Better Bridges Kit ME-3581
(Includes PS-3216)

Structures Systems

Truss Set

ME-6990

- Teach the basics of trusses
- Demonstrate the properties of I-Beams

Plastic I-Beams

Plastic Connectors

Steel Thumb Screws

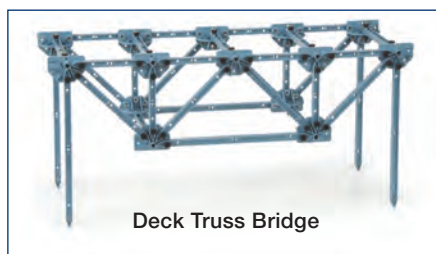
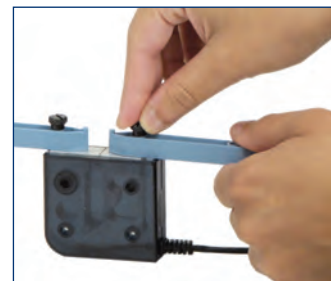
Use the Truss Set to build a variety of structures to investigate the principles of trusses. The ABS plastic I-Beams fasten securely together using the provided connectors and thumb screws. Load cells can be inserted anywhere into the design by replacing one beam at a time. Students can load the truss by hanging weights.

Measure the compression and tension in the I-Beam members by adding optional Load Cells.

Through Truss with Verticals

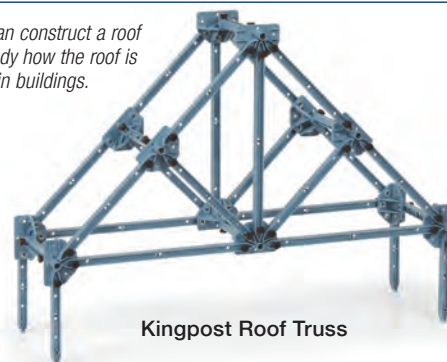
Construction is easy: I-Beams fit into the connectors and are secured with thumbscrews. Thumbscrews are also slotted so a screwdriver can be used.

I-Beams key into the Load Cell and are fastened with thumbscrews.



Deck Truss Bridge

Students can construct a roof truss to study how the roof is supported in buildings.



Kingpost Roof Truss

Includes:

- I-Beam #5 24 cm long (8)
- I-Beam #4 17 cm long (18)
- I-Beam #3 11.5 cm long (18)
- I-Beam #2 8 cm long (8)
- I-Beam #1 5.5 cm long (8)
- Connectors (14)
- Screws (75)
- Instruction Manual

**Order Information**

Truss SetME-6990

Recommended:

Load Cell and Amplifier SetPS-2199

p. 159

Bridge Set

ME-6991

- Larger quantity of I-Beams and connectors
- Study the principles of bridge construction
- Road bed and car add realism to bridges
- Add Load Cells to see dynamic loading as car traverses bridge

Flexible Road Bed

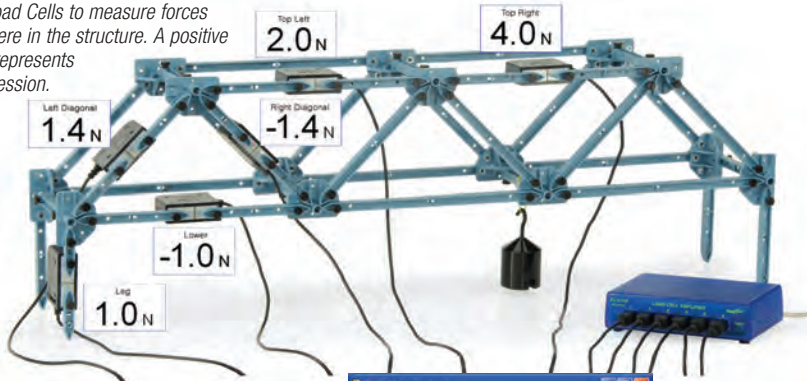
Car with Mass

Cross-bracing

Verticals to support road bed

The Bridge Set allows students to build larger trusses, bridges, and even roller coasters! It includes extra materials, such as a flexible Road Bed and Car for studying dynamic loading as the car traverses the bridge. Use the special cord locks to create tension in the cord and investigate cross-bracing, or measure the tension and compression of each element in real time with Load Cells. The Flexible Road Bed clips securely to cross-beams, making it easy for students to measure the effects of dynamic loading across the structure..

Add Load Cells to measure forces anywhere in the structure. A positive value represents compression.



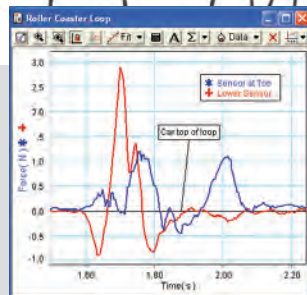
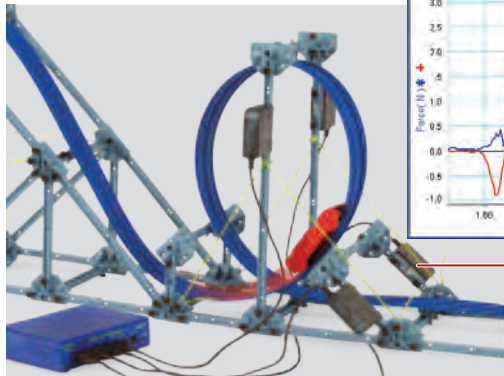
Howe

Pratt

Warren

Students can build several types of fundamental bridges including Howe, Pratt, and Warren bridges.

Design your own roller coaster!



Add Load Cells to measure the forces needed to support the track as the car goes up and over the loop.

Includes:

- I-Beam #5 (16) 24 cm long (16)
- I-Beam #4 (36) 17 cm long (36)
- I-Beam #3 (36) 11.5 cm long (36)
- I-Beam #2 (16) 8 cm long (16)
- I-Beam #1 (16) 5.5 cm long (16)
- Connectors (28)
- Screws (150)
- Flexible road bed (3 m)
- Track coupler
- Road bed clips (24)
- Car with flag and mass

- Starter bracket
- Cord tensioning clips (32)
- Yellow cord (1 roll)
- Instruction manual

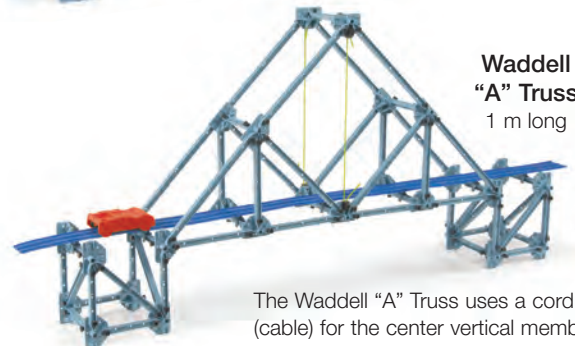


Deck Truss

80 cm long



Waddell
"A" Truss
1 m long



The Waddell "A" Truss uses a cord (cable) for the center vertical member.

Order Information

Bridge Set.....ME-6991

Recommended:

Load Cell and Amplifier Set.....PS-2199 p. 159

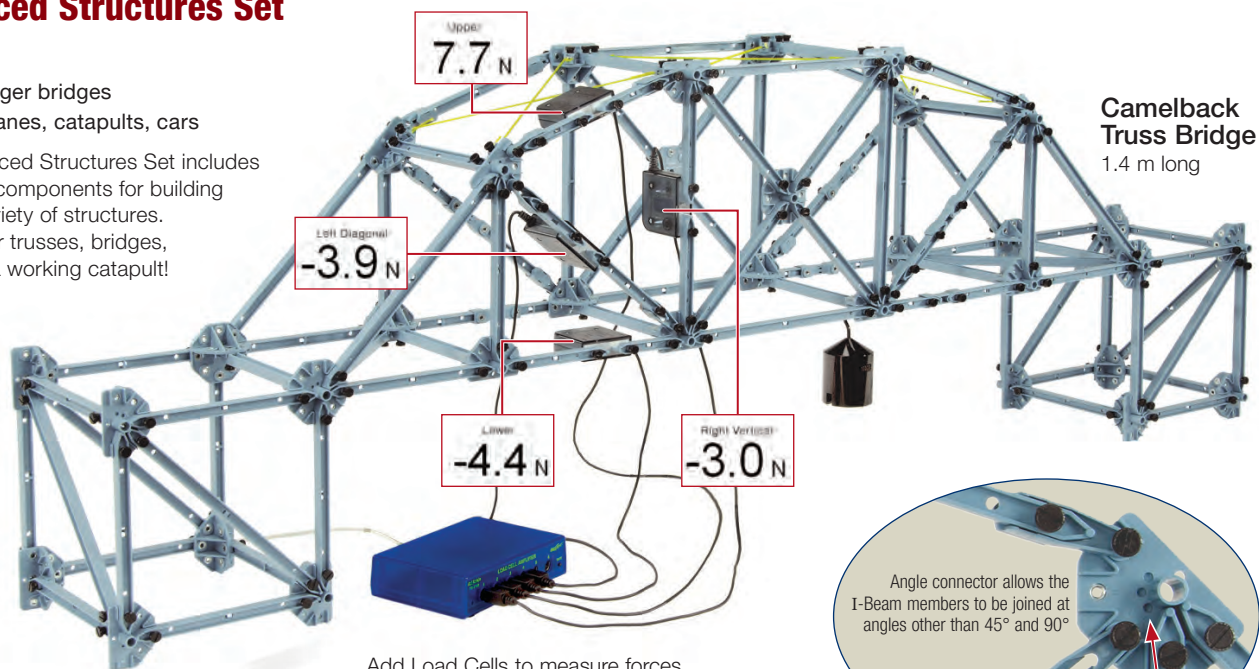
Structures Systems

Advanced Structures Set

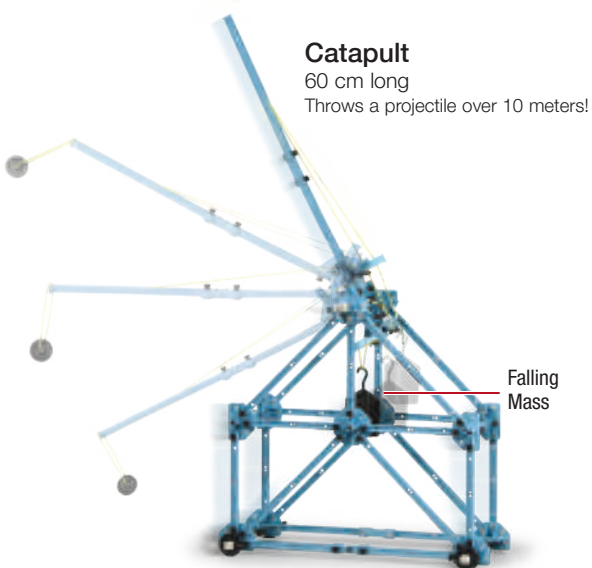
ME-6992B

- Build larger bridges
- Build cranes, catapults, cars

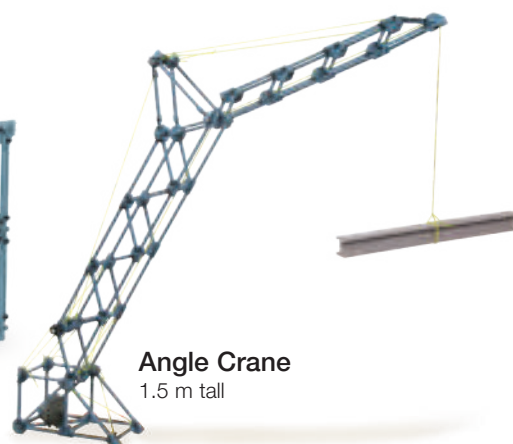
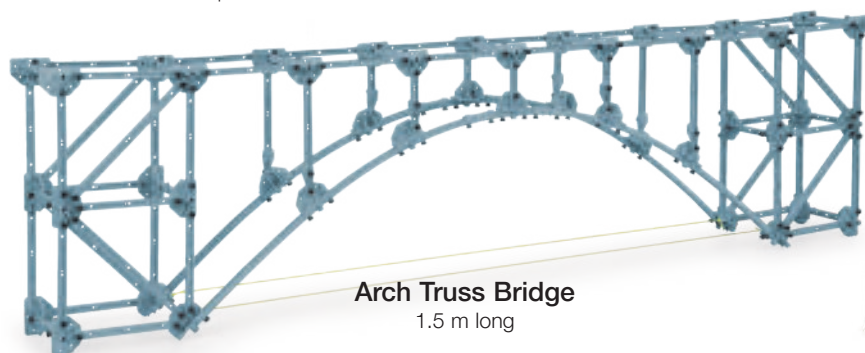
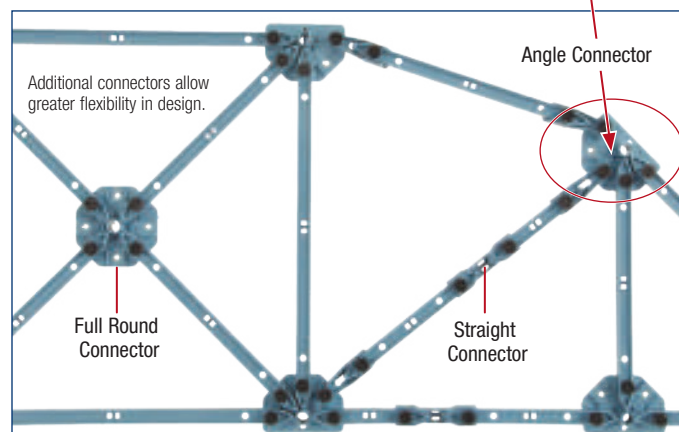
The Advanced Structures Set includes additional components for building a wider variety of structures. Build larger trusses, bridges, and even a working catapult!



Add Load Cells to measure forces anywhere in the structure.



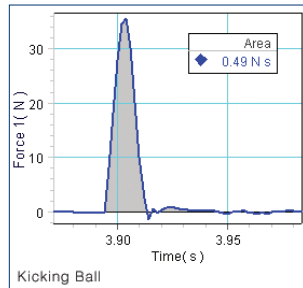
Wheels allow catapult to move.



Also see the Tower Crane on page 165.

Human Leg Model

The articulated leg, shown below, uses a rubber band (not included) for the quadriceps and has a load cell on the foot to measure the force that the “toe” exerts on the ball. The impulse (area under the curve) is equal to the resulting momentum of the ball.



Rubber Band

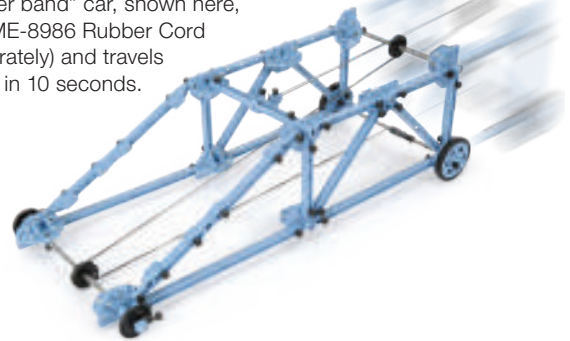
Load Cell

See page 169 for more Human Structures.

Rubber Band Car

Build a working catapult, a car with rubber band suspension, and a rubber band-powered car.

The “rubber band” car, shown here, uses the ME-8986 Rubber Cord (sold separately) and travels over 50 ft. in 10 seconds.



Use these flexible I-Beams to make a bridge which dramatically demonstrates how a bridge fails and yet the beams will return to their original shape when the load is removed.

For more examples using the Advanced Structures Set go to pasco.com/structures

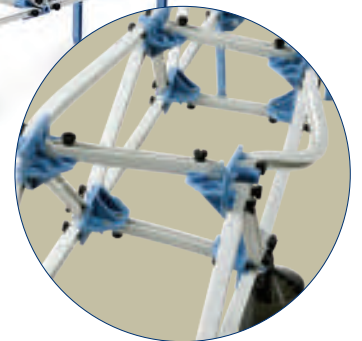


Includes:

- Force Platform Bracket (2)
- I-Beam #5 24 cm long (24)
- I-Beam #4 17 cm long (54)
- I-Beam #3 11.5 cm long (54)
- I-Beam #2 8 cm long (24)
- I-Beam #1 5.5 cm long (24)
- Flex I-Beam #5 24 cm long (10)
- Flex I-Beam #4 17 cm long (18)
- Flex I-Beam #3 11.5 cm long (18)
- Flat Beams (3 lengths) (16)
- Axles (3 lengths) (2)
- Connectors (42)
- Cord Tensioning Clips (32)
- Round and Flat Connectors (6)
- PASTrack Fasteners (6)
- Angle and Straight Connectors (24)
- Sliding Connector (12)
- Pulleys, O-rings, Spacers (12)
- Collets (24)
- Drive Wheel with Rubber Tire (4)
- Structures Rod Clamps (2)
- Screws (300)
- Yellow Cord (1 roll)
- Instruction Manual



Flexible I-Beams
Dramatically demonstrate structural failure.



Order Information

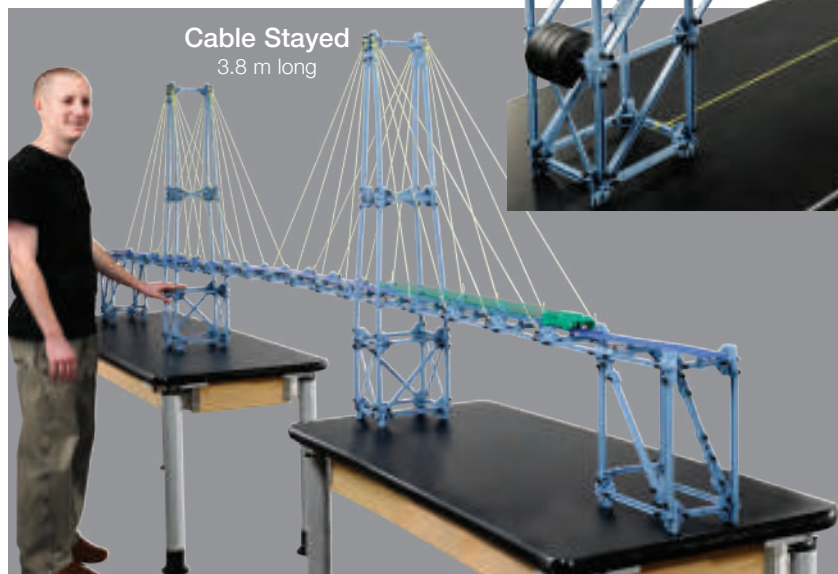
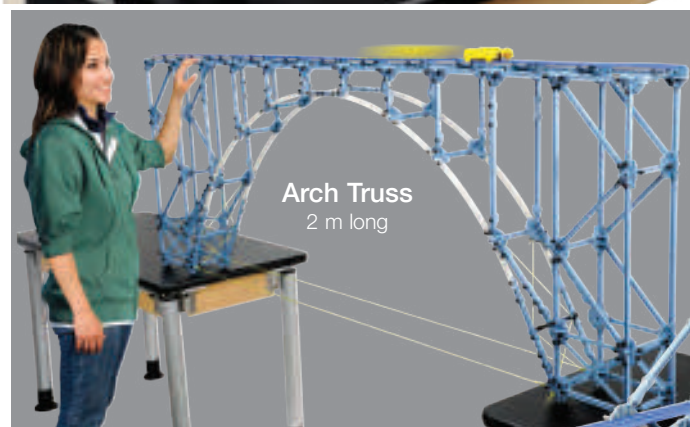
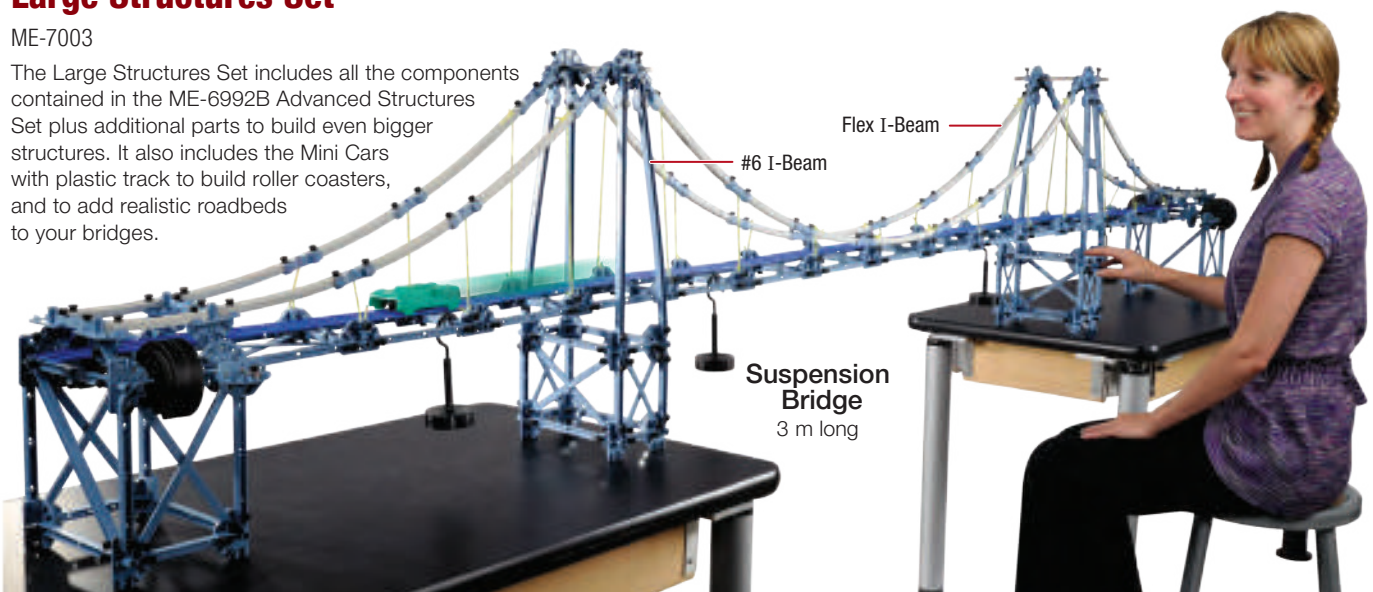
Advanced Structures Set.....	ME-6992B	
Shown in use with:		
Load Cell and Amplifier Set	PS-2199	p. 159
(includes four load cells)		
100 N Load Cell	PS-2200	p. 159
Large Slotted Mass Set	ME-7566	p. 215
Rubber Cord for IDS System (30m spool)	ME-8986	p. 120

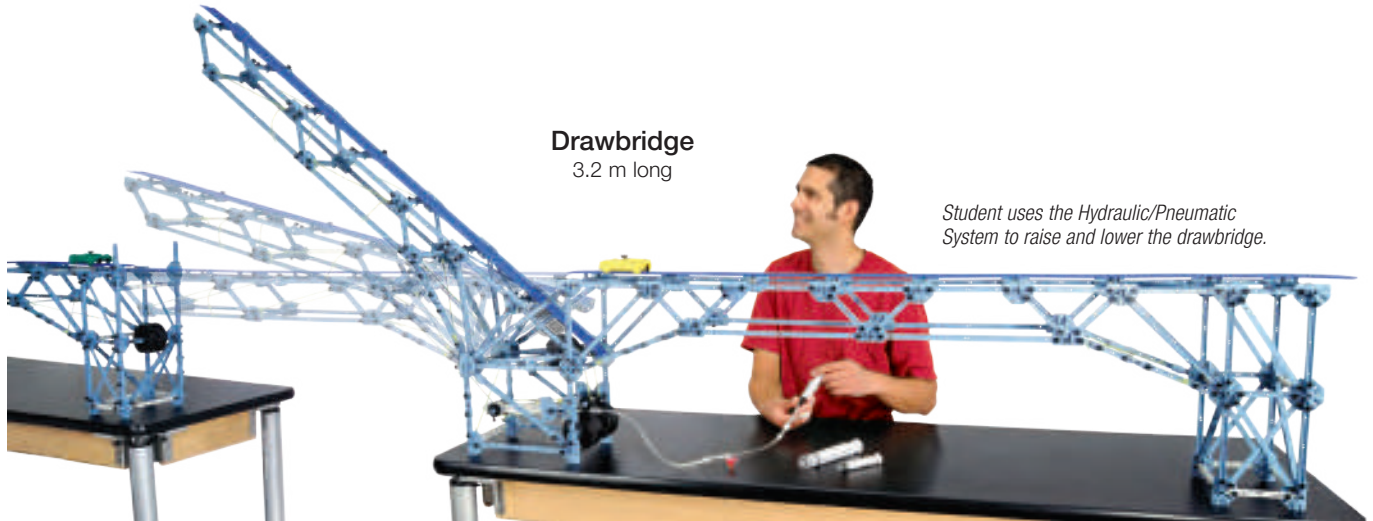
Structures Systems

Large Structures Set

ME-7003

The Large Structures Set includes all the components contained in the ME-6992B Advanced Structures Set plus additional parts to build even bigger structures. It also includes the Mini Cars with plastic track to build roller coasters, and to add realistic roadbeds to your bridges.



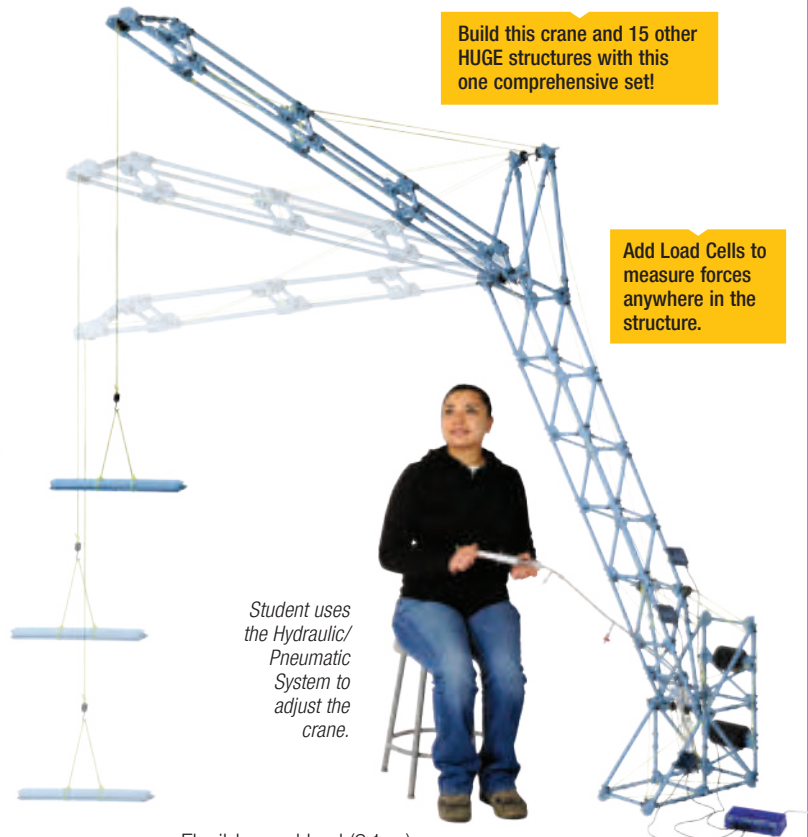


Drawbridge
3.2 m long

Student uses the Hydraulic/Pneumatic System to raise and lower the drawbridge.



Tower Crane
1.2 m tall



Build this crane and 15 other HUGE structures with this one comprehensive set!

Add Load Cells to measure forces anywhere in the structure.

Student uses the Hydraulic/Pneumatic System to adjust the crane.

Includes:

- I-Beam #6 35 cm long (24)
- I-Beam #5 24 cm long (24)
- I-Beam #4 17 cm long (54)
- I-Beam #3 11.5 cm long (54)
- I-Beam #2 8 cm long (24)
- I-Beam #1 5.5 cm long (24)
- Flex I-Beam #5 24 cm long (10)
- Flex I-Beam #4 17 cm long (18)
- Flex I-Beam #3 11.5 cm long (18)
- Flat Beams (3 lengths) (16)
- Axles (3 lengths) (2)
- Connectors (70)
- Cord Tensioning Clips (32)
- Yellow car and green car, each with flag
- Force Platform Bracket (2)
- Round and Flat Connectors (6)
- Angle and Straight Connectors (24)
- Drive Wheel with Rubber Tire (4)
- Pulleys, O-rings, Spacers (12)
- Structures Rod Clamps (2)
- Sliding Connector (12)
- PASTrack Fasteners (6)
- Collets (24)
- Screws (450)
- Yellow Cord (1 roll)

- Flexible road bed (9.1 m)
- Road bed clips (24)
- Starter bracket
- Track coupler (2)
- Instruction Manual

Order Information

Large Structures Set.....	ME-7003	
Shown in use with:		
Load Cell and Amplifier Set	PS-2199	p. 159
(includes four load cells)		
Structures Hydraulic System.....	ME-6984	p. 170
Large Slotted Mass Set (2 kg Set)	ME-7589	p. 215

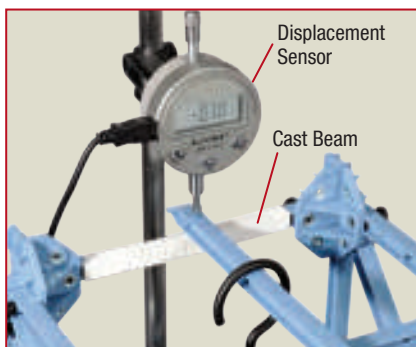
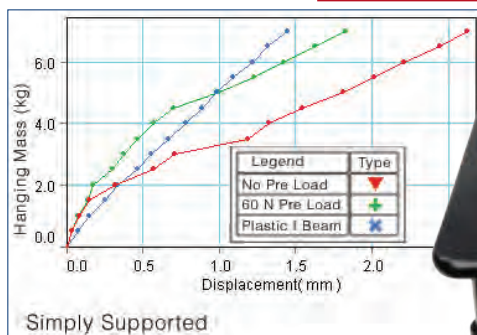
Structures Systems

Structures Cast Beam Set

ME-7009

Make your own cast beams that look like pre-stressed concrete beams. Test them and you'll find they perform like them, too. These beams are cast with a mixture of sand and plaster of paris (not included). The rebar is made of the same plastic used for the I-beams. Students can explore how the strength of the beam is affected by the amount of tension put on the rebar, the mixture of sand and plaster of paris, or the number of rebar used.

The graph of hanging mass versus displacement shows the relative strengths of three beams: one cast beam made with no pre-load; one cast beam made with 60 N of pre-load; and one normal plastic I-beam. Notice that the traces for the cast beams show discontinuities when the beams cracked. Also notice that the pre-loaded cast beam is stronger than the plastic I-beam until the cast beam cracks.



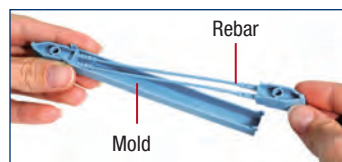
The tension fixture and the test fixture can be built concurrently with this set.

Test Fixture

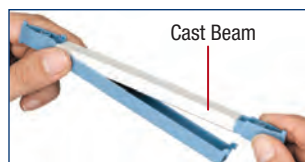
Displacement of beam is measured as load is increased.

Tension Fixture

The beam rebar is kept under tension while the beam is drying.



Step 1: The rebar with connecting ends snaps into the plastic mold. Pour a mixture of sand and plaster of paris into the mold.



Step 2: After it dries, the cast beam is easily removed from the plastic mold.

Includes:

- I-Beam #5 24 cm long (8)
- I-Beam #4 17 cm long (18)
- I-Beam #3 11.5 cm long (18)
- I-Beam #2 8 cm long (8)
- I-Beam #1 5.5 cm long (8)
- Axles (3 lengths) (2)
- Connectors (14)
- Cord Tensioning Clips (32)
- Round and Flat Connectors (6)
- PASTrack Fasteners (6)
- Angle and Straight Connectors (24)
- Collets (24)
- Screws (150)
- Pulley, O-rings, Spacers (12)

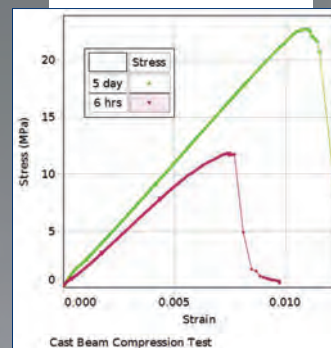
- Sliding Connector (12)
- Reusable Plastic Molds (10)
- Rebar (30)
- Yellow Cord (1 roll)
- Instruction Manual

Required but not included:

- Sand and Plaster of Paris



The cast beam shown here is tested to destruction under compression using the Materials Testing Machine on page 174.



PASCO Capstone graph shows that the strength of plaster of paris increases with cure time.

Cast Beam Spares Set

ME-6983

Consumable replacement parts for Cast Beams. These can also be used with the Advanced Structures Set.

Includes:

- Reusable Plastic Molds (10)
- Rebar with Connectors (30)



Order Information

Cast Beam Spares SetME-6983

Order Information

Structures Cast Beam Set.....ME-7009

Also shown:

PASPORT Displacement Sensor.....PS-2204 p. 38

Large Slotted Mass Set.....ME-7566 p. 215

Not shown, but required:

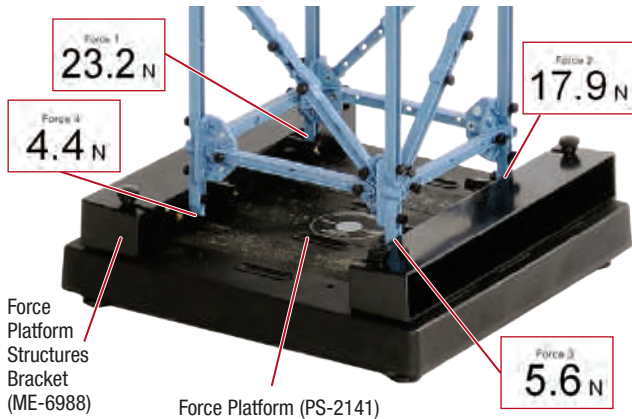
Interface and PASCO Capstone Software, see pages 8-11.

Measure support forces with a Force Platform

PASPORT Force Platform

PS-2141

Measure the support forces of a crane by connecting it to a Force Platform (PS-2141) using the special Force Platform Structures Bracket (ME-6988). The Force Platform is supported by four individual load cells which combine to measure the total vertical force on the platform. These four readings can also be viewed separately to measure the unequal forces on the crane supports.



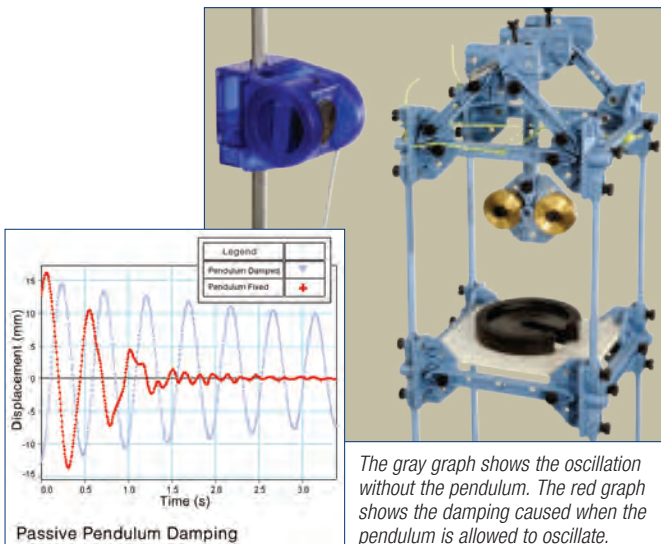
Build the crane using the Large Structures Set (ME-7003), shown on pages 164-165.

Order Information

PASPORT Force Platform.....	PS-2141
Force Platform Structure Bracket	ME-6988A

Measure passive damping with a Motion Sensor

This building frame is built with an Advanced Structures Set using the Flat Members. A pendulum with drag caused by strings is suspended from the top of the building. The Motion Sensor is positioned to record the oscillation of the building.



Measure bridge deflection with a Displacement Sensor

PASPORT Displacement Sensor

PS-2204

The Displacement Sensor measures the travel of a spring-loaded indicator as a bridge is loaded with weight. The included PASPORT Sensor plugs into the included Digital Indicator, which has its own digital LED readout and can be used as a standalone device. To record your data, simply plug the PASPORT sensor into an interface.

Specifications:

Maximum Travel: 10 mm

Maximum Sample Rate: 5 Hz

Resolution:

0.013 mm

(0.0005 in)



Order Information

PASPORT Displacement Sensor.....	PS-2204	
Shown in use with:		
Hooked Mass Set.....	SE-8759	p. 215
Small A-Base with Leveling Feet.....	ME-8989	p. 204
Stainless Steel Rod, 60 cm Threaded.....	ME-8977	p. 204
Required:		
PASPORT Interface.....		p. 18

Order Information

Equipment shown:	
Advanced Structures Set*	ME-6992B
PASPORT Motion Sensor	PS-2103A
Large Slotted Mass Set.....	ME-7566
*Patents pending	p. 215

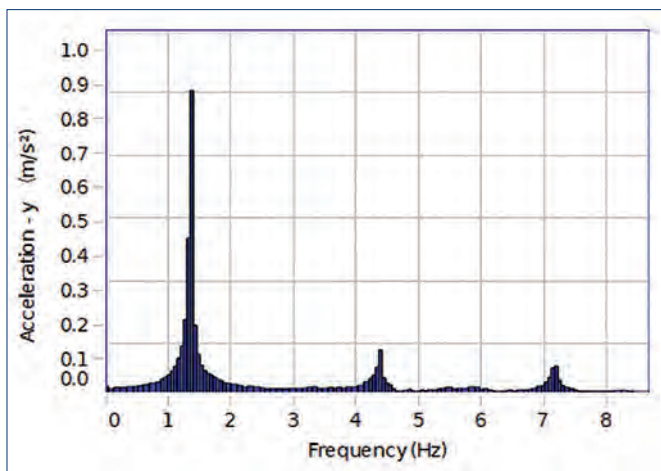
Structures Systems

Shaking Tower

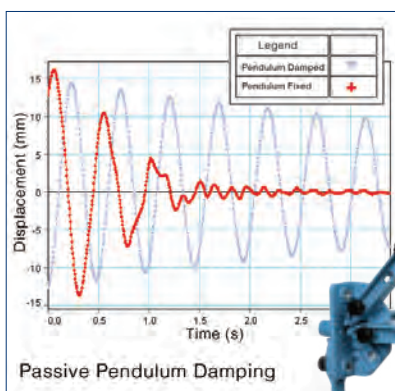
ME-7018

- Explore the resonance modes
- Measure accelerations with Wireless Sensors
- Demonstrate passive damping

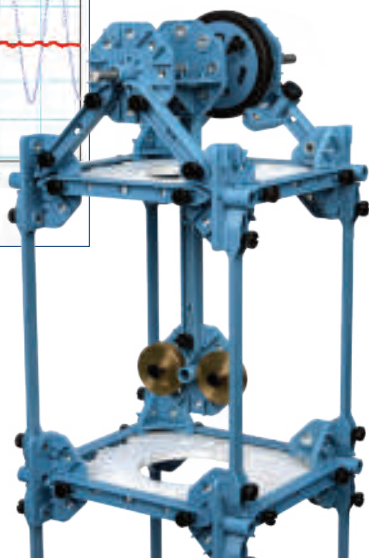
Built from PASCO Structures beams, this tower is made to oscillate in its various resonance modes by a driver attached by a rubber band to the first floor of the tower. Wireless Load Cells with Accelerometers are attached to each floor to record how much shaking each floor experiences.



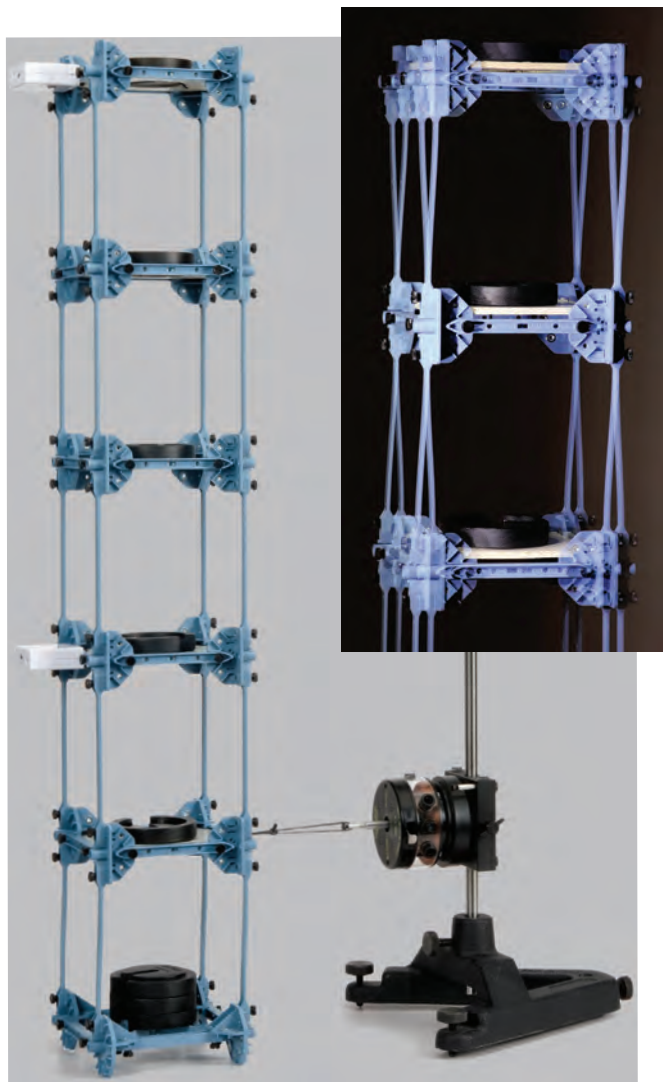
This FFT, generated in PASCO Capstone software, shows the frequency responses of the top Wireless Load Cell/Accelerometer.



The gray graph in PASCO Capstone software shows the oscillation without the pendulum. The red graph shows the damping caused when the pendulum is allowed to oscillate.



In modern buildings, passive damping mechanisms are installed to damp out oscillations during earthquakes. The damping pendulum in this tower quickly stops oscillations.



The tower is shaken by the Mechanical Wave Driver, which is powered by an 850 Universal Interface or Function Generator.

Includes:

- #1 I-Beams (10)
- #2 I-Beams (8)
- #3 I-Beams (24)
- #4 I-Beams (1)
- Nylon Spacers (2)
- Connectors (20)
- (F4) Flat Beam (20)
- Flat Round Connector (4)
- Full Round Connectors (5)
- Floors (5)
- Mass, 20 gram (2)
- Mass, 50 gram (2)
- Medium Shaft, Structures
- Screws (2 sets) (150)
- Sliding Connector
- Tire, Structures
- Wheel, Structures

(Large Slotted Mass Set, shown in photo above, not included.)

Order Information

Shaking Tower	ME-7018	
Required:		
Large Slotted Mass Set	ME-7566	p. 215
Wave Driver	WA-9855	p. 280
2 Meter Patch Cord Set	SE-9415A	p. 248
Large Rod Base	ME-8735	p. 204
Round Base with Rod	ME-8270	p. 204
Wireless Load Cell and Accelerometer	PS-3216	p. 159
850 Universal Interface	UI-5000	p. 20
PASCO Capstone Software		pp. 8-11

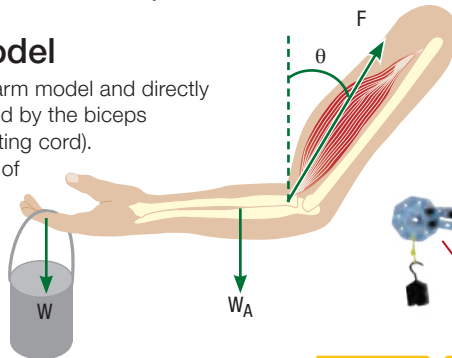
Human Structures Set

ME-7001

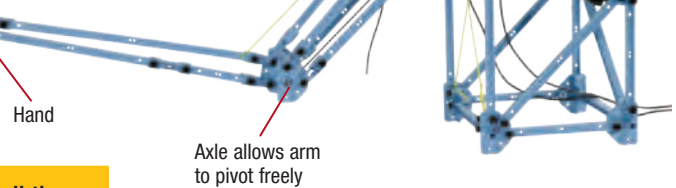
- Bring kinesiology topics to life!
- Build models that represent real life examples.
- Construct all three models concurrently with this set.

Human Arm Model

Students build a realistic arm model and directly measure the forces exerted by the biceps muscle (tension in supporting cord). Vary the length and angle of the upper and lower arm, as well as the point of attachment of the muscle.



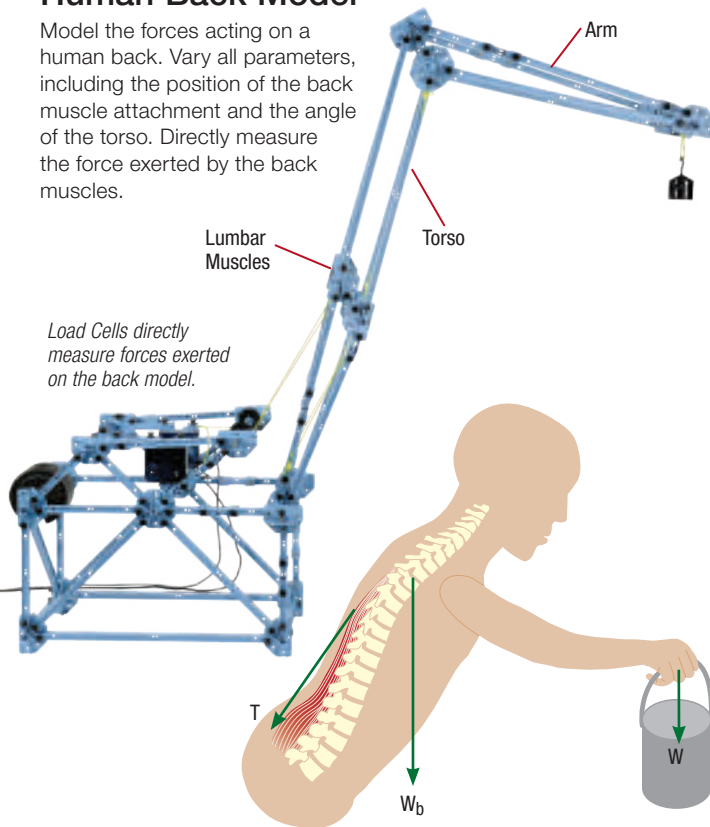
Load Cell represents the biceps muscle



Construct all three models concurrently with this set.

Human Back Model

Model the forces acting on a human back. Vary all parameters, including the position of the back muscle attachment and the angle of the torso. Directly measure the force exerted by the back muscles.

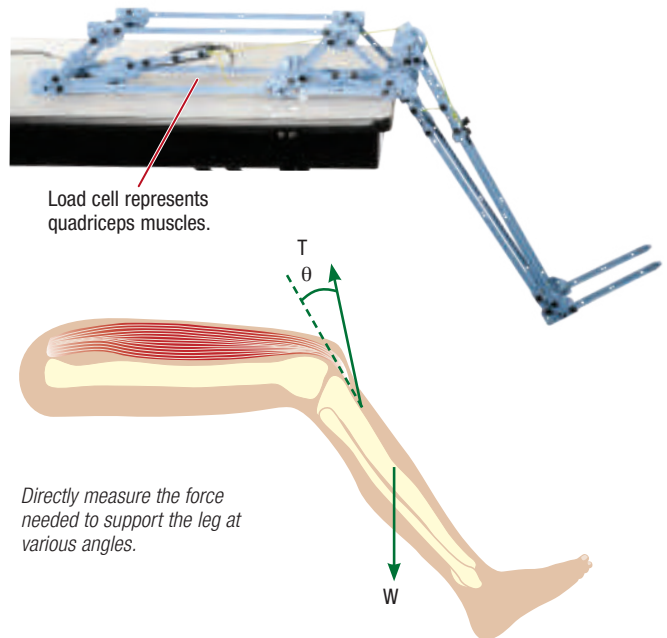


Includes:

- Truss Set Screws (5-pack)
- Truss Set Members (2-pack)
- Connector Spares (2-pack)
- #6 I-Beam Spares (1 pkg.)
- Cord Lock Spares (1 pkg.)
- Axle Spares (1 pkg.)
- Round Connector Spares (1 pkg.)
- Angle Connector Spares (1 pkg.)
- Roll of rubber cord

Human Leg Model

The leg model shown below uses a Load Cell for the quadriceps muscle to directly measure the force needed to support the leg at various angles.



Directly measure the force needed to support the leg at various angles.

Order Information

Human Structures Set.....ME-7001

Shown in use with:

Load Cell and Amplifier Set.....PS-2199

(includes four load cells)

Hooked Mass Set.....SE-8759

Large Slotted Mass Set.....ME-7566

p. 215

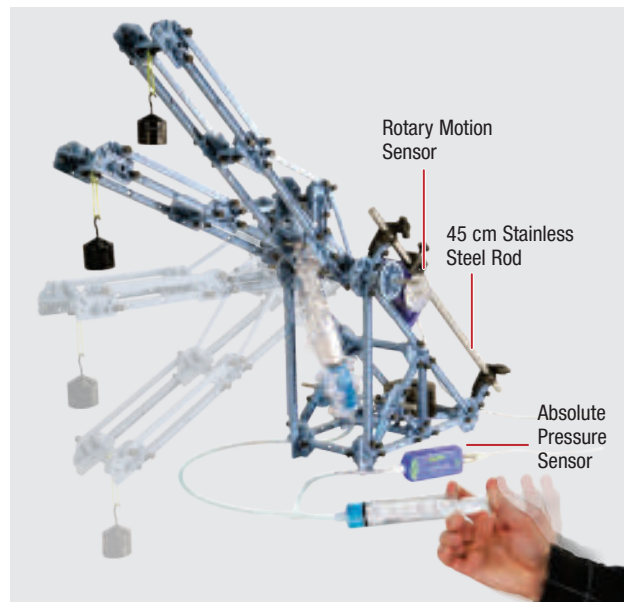
p. 215

Structures Systems

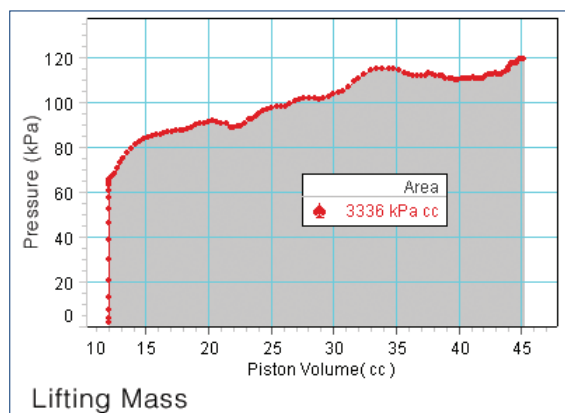
Structures Hydraulic System

ME-6984

Add a hydraulic/pneumatic ram to make your structures move and do work. Not only will students see the cranes and jacks in action, they can directly measure the pressure and volume to calculate how much work was done.



The weight is lifted using a syringe of water to fill the master cylinder. An Absolute Pressure Sensor measures the pressure and a Rotary Motion Sensor records the movement of the piston.



Pressure and volume are recorded as the weight is lifted, and the work done is the area under the curve.

Includes:

- Master Cylinder
- Pressure Sensor "T"
- Check Valves and Tubing
- Syringes (10, 20, 60 ml)
- Drive Belt for Rotary Motion Sensor (not shown)

**Order Information**

Structures Hydraulic System	ME-6984	
Advanced Structures Set	ME-6992B	p. 162
45 cm Stainless Steel Rod	ME-8736	p. 204
PASPORT Absolute Pressure Sensor	PS-2107	p. 39
PASPORT Rotary Motion Sensor	PS-2120A	p. 35

6-Way Structures Connector (set of 6)

ME-7019

- For multi-room, multi-level buildings

This connector is for construction of multi-room, multi-level buildings using PASCO Structures. The 6-Way Structures Connector allows connections in six directions (positive and negative x-, y-, and z-directions).

**Order Information**

6-Way Structures Connector (set of 6).....ME-7019

Building Better Bridges Kit

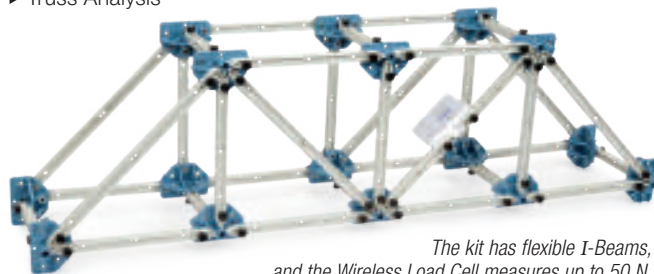
ME-3581

- A complete STEM kit to teach bridge-building
- Compatible with PASCO Structures System

Now is the perfect time for your students to learn about bridge-building and how bridges really work. This complete STEM kit allows students to learn and apply engineering design concepts. They can use the included I-Beams to build bridges and structures that behave like the real thing! And with the included Wireless Load Cell, students can measure forces under tension or compression anywhere in their structures.

Concepts:

- Forces in Equilibrium
- Internal Forces
- Moments in Equilibrium
- Strength of Members
- Truss Analysis



The kit has flexible I-Beams, and the Wireless Load Cell measures up to 50 N.

Includes:

- Lab Activities
- Wireless Load Cell and Accelerometer PS-3216
- Flexible I-Beams (various sizes)
- Connectors
- Truss Screws
- Weight Set
- Grattells® Storage Tray

**Order Information**

Building Better Bridges Kit	ME-3581	
Want an additional Load Cell?		
Wireless Load Cell and Accelerometer	PS-3216	p. 159

Flexible I-Beam Set

ME-6985

Use the flexible I-Beams to make a bridge that dramatically demonstrates how a bridge fails. The beams return to their original shape once the load is removed.



Dramatically demonstrate structural failure.



Includes:

- Flexible I-Beam #5, 24 cm long (10)
- Flexible I-Beam #4, 17 cm long (18)
- Flexible I-Beam #3, 11.5 cm long (18)

Order Information

Flexible I-Beam Set ME-6985
Shown in use with:
Truss Set ME-6990 p. 160

Mini Car Track Spares

ME-6974



Includes two gates, two track couplers and one bag (24) of roadbed clips.

Order Information

Mini Car Track Spares ME-6974

Axle Spares

ME-6998A



Includes drive wheel with rubber tire (4), pulleys with "O" rings (12 each), axles (two each of three lengths), spacers (12) and collets (24).

Order Information

Axle Spares ME-6998A

Cord Lock Spares

ME-6996

Includes 32 cord-tensioning clips and a spool of yellow cord.

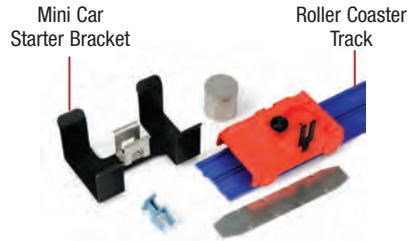


Order Information

Cord Lock Spares ME-6996
Yellow String (2 pack) ME-9876

Road Bed Spares

ME-6995



Includes flexible roadbed (3 m), roadbed clips (24), car with flag, extra mass, mini car starting bracket, and track couples (2).

Order Information

Road Bed Spares ME-6995
Sold separately:
Roller Coaster Track ME-9814

Force Platform Structure Bracket

ME-6988A

Includes:

- Brackets (2)
- Screws (4)



Order Information

Force Platform
Structure Bracket ME-6988A

Truss Set Members

ME-6993

Includes:

- I-Beam #5 24 cm long (8)
- I-Beam #4 17 cm long (18)
- I-Beam #3 11.5 cm long (18)
- I-Beam #2 8 cm long (8)
- I-Beam #1 5.5 cm long (8)
- Connectors (14)



Order Information

Truss Set Members ME-6993

Truss Set Screws

ME-6994

Includes 80 screws. All components in the Structures System use this same 6-32 thumbscrew.



Order Information

Truss Set Screws ME-6994

Structures Rod Clamp

ME-6986

Connects structure members to 1/2" rod. Includes a set of two.



Order Information

Structures Rod Clamp ME-6986

Beams & Connectors

Thin I-Beams

ME-7012

Set of 48 thin I-Beams, for use with PASCO Structures. 24 each of #4 beams (17 cm length) and #3 beams (11.5 cm length).



Flexible I-Beam Set

ME-6985

Includes 18 each of:

Flexible I-Beam #4 (17 cm long)
Flexible I-Beam #3 (11.5 cm long)
and 10 Flexible I-Beam #5 (24 cm long)



Flat Structures Members

ME-6987

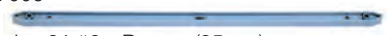
Includes 16 each of:
2x3 beams (12.5 cm long); F4 beams (17 cm long); 3x4 beams (19 cm long)



Structures #6 I-Beam Spares

ME-7008

Includes 24 #6 I-Beams (35 cm)



Structures #5 I-Beam Spares

ME-7017

Includes 24 #5 I-Beams (24 cm)



Photoelastic I-Beam Set

ME-7011

Clear plastic I-Beams that display stress lines.

Includes 24 each of:
#3 I-Beam (11.5 cm long)
#4 I-Beam (17 cm long)



Order Information

Thin I-Beams ME-7012
Flexible I-Beam Set ME-6985
Flat Structures Members ME-6987
Structures #6 I-Beam Spares ME-7008
Structures #5 I-Beam Spares ME-7017
Photoelastic I-Beam Set ME-7011

Connector Spares

ME-7002

Set of 14 Connector Spares used to join truss members.



Angle Connector Spares

ME-6999A

Includes 24 each of Angle Connectors, Straight Connectors and 12 Sliding Connectors.



Full Round and xyz Connector Spares

ME-6997

Includes 6 each of: full round connectors, xyz connectors, and bolts & nuts.



Order Information

Connector Spares ME-7002
Angle Connector Spares ME-6999A
Full Round and xyz
Connector Spares ME-6997

Materials Testing

Comprehensive Materials Testing System

ME-8244

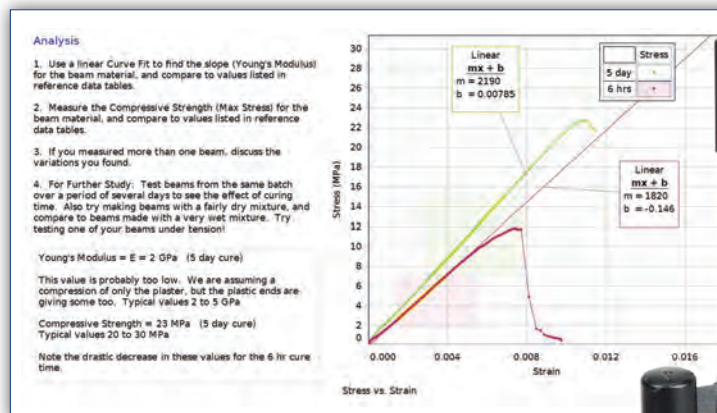
With this one system,
your students can investigate:

- Compression and tensile testing
- Column buckling
- Three and four-point bending
- Shear testing
- Stress lines with photoelasticity

The Comprehensive Materials Testing System includes everything needed to investigate compression and tensile testing, column buckling, three and four-point bending, shear testing, and stress lines with photoelasticity. In addition to everything the Materials Testing Machine provides, the Comprehensive System includes a sturdy, plastic base with convenient storage for all components and accessories.



Download **FREE** experiments at pasco.com/MTS



Clear Safety Shields

Materials Testing Machine

Tensile Samples

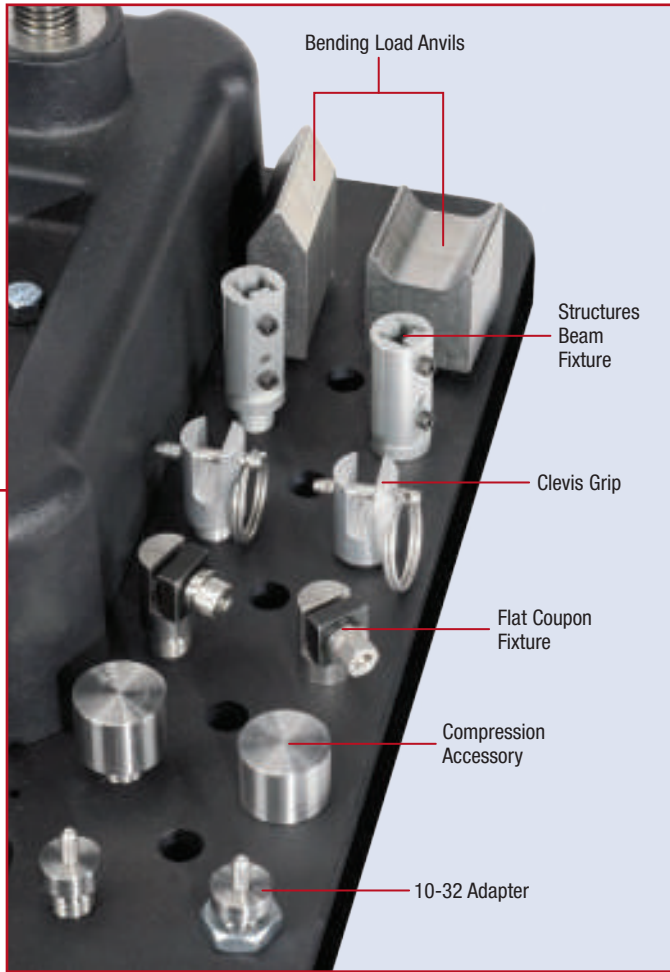
Calibration Rod

System Storage Base

Sturdy plastic base provides convenient storage for accessories. Use a C-clamp on the corner of the base to temporarily secure the Materials Testing Machine to the lab bench.

Bending Support Anvil

Shear Accessory



Includes:

- Materials Testing Machine ME-8236
- Tensile Samples:
Aluminum, Brass, Annealed Steel,
Steel, Acrylic, Polyethylene (10 of each)
- Bending Accessory ME-8237
- Four-point Load Anvil ME-8249
- Photoelasticity Accessory ME-8241
- Shear Accessory ME-8239
- Materials System Storage Base ME-8229
- Structures Beam Fixture ME-8242
- Thin I-Beams ME-7012
- Cast Beam Spares Set ME-6983
- Compression Accessory ME-8247
- Flat Coupon Fixture ME-8238
- Stress Strain Apparatus
Coupons – Plastic AP-8222
- Stress Strain Apparatus
Coupons – Metal AP-8223
- Clevis Grip ME-8245
- 10-32 Adapter ME-8246
- AirLink Interface PS-3200
- PASCO Capstone Software



Order Information

Comprehensive Materials Testing System	ME-8244
Materials Testing Machine	ME-8236

Materials Testing

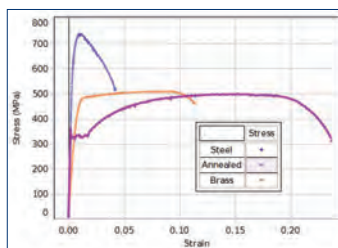
Materials Testing Machine

ME-8236

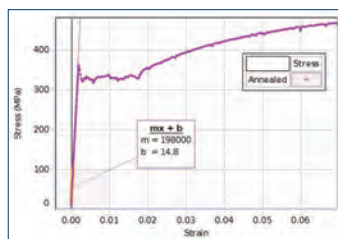
- ▶ 7100 N max load
- ▶ Hand-cranked so students can feel samples break
- ▶ Inexpensive samples make it possible for each student to experience it firsthand

Measure force and displacement for various materials as they are stretched, compressed, sheared, or bent. Investigate material properties including Young's Modulus, Tensile Strength, Yield Strength, Ductility and Modulus of Resilience.

The Materials Testing Machine measures force with a 7100 N load cell and displacement with an optical encoder. It runs on PASCO Capstone software, which has a built-in compliance calibration wizard and has all the tools to record and display stress vs. strain, apply linear fits to find Young's Modulus, and to record and play back video of the samples breaking in sync with the data.



Tensile Stress vs. Strain is plotted in PASCO Capstone software for steel, annealed steel, and brass.



For annealed steel, a linear fit is applied to find Young's Modulus.

ME-8236 Includes

- Machine
- Compliance calibration rod
- Safety shields

(requires Capstone software)



Tensile Samples

Set of 10 each

Order Information

Aluminum Tensile Sample	ME-8231
Brass Tensile Sample	ME-8232
Annealed Steel Tensile Sample	ME-8233
Steel Tensile Sample	ME-8243
Acrylic Tensile Sample	ME-8234
Polyethylene Tensile Sample	ME-8235

Specifications:

Load Cell Capacity:
7100 N (1600 lbs)

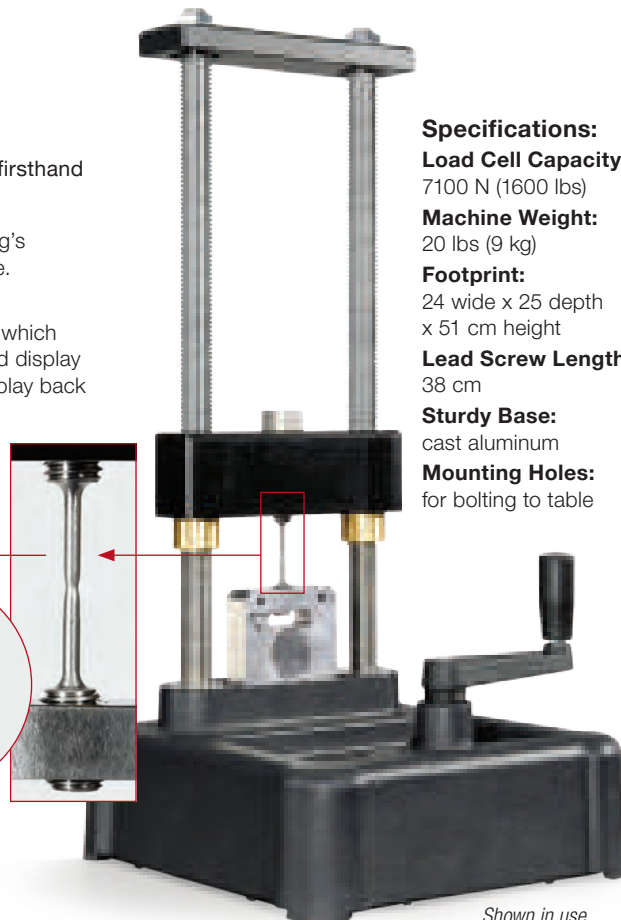
Machine Weight:
20 lbs (9 kg)

Footprint:
24 wide x 25 depth
x 51 cm height

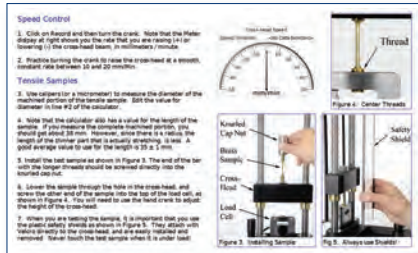
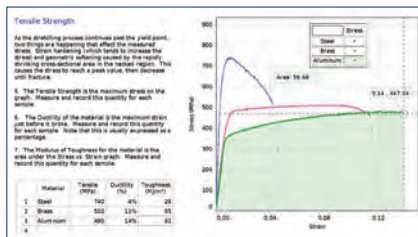
Lead Screw Length:
38 cm

Sturdy Base:
cast aluminum

Mounting Holes:
for bolting to table



Shown in use without the included safety shields.



FREE Download
[www.pasco.com/
MaterialsTester](http://www.pasco.com/MaterialsTester)

Workbooks include all instructions needed to perform the experiment:

- ▶ Introduction and theory
- ▶ Setup instructions
- ▶ Detailed analysis and summary questions

Order Information

Materials Testing Machine	ME-8236
Required:	
PASCO Capstone Software	pp. 8-11
AirLink Interface	PS-3200 p. 50
Tensile Samples (at left)	

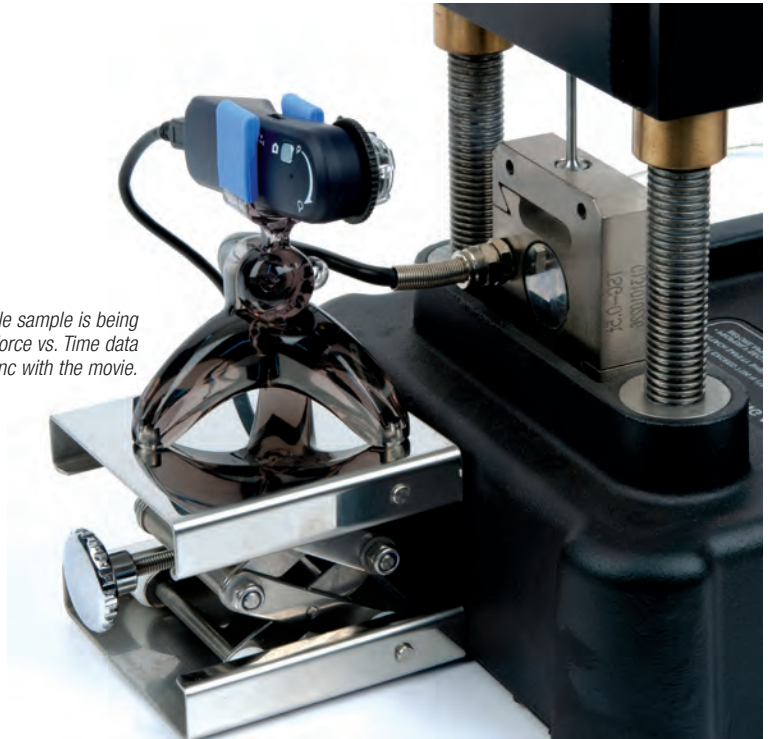
Sync Video to Stress-Strain Data

Use a USB webcam to video the sample while collecting stress-strain data. In PASCO Capstone, the video will automatically sync to the data and the video and data on the graph can be played back at normal speed or slow motion. This allows students to see what is happening physically to the sample correlated to the bending of the Stress versus Strain curve on the graph.



Image of broken steel tensile sample taken with a microscope.

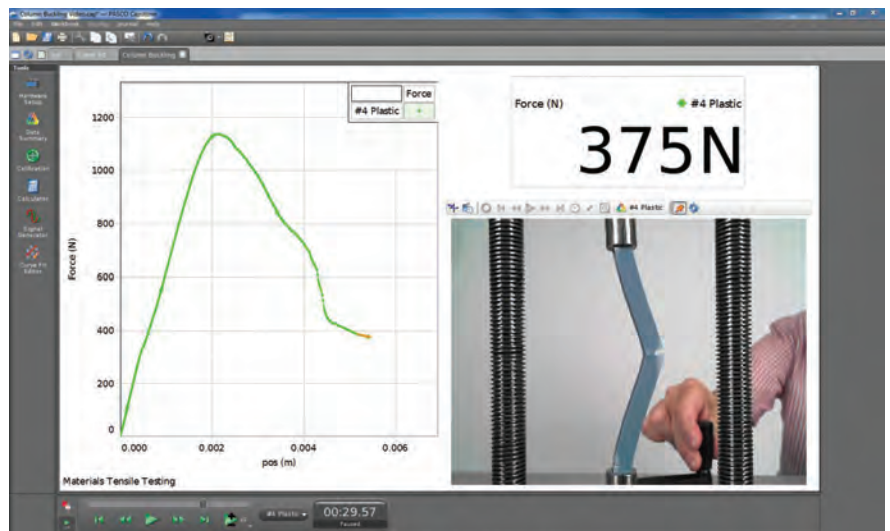
As the tensile sample is being stretched, the Force vs. Time data is graphed in sync with the movie.



PASCO capstone™
Software

Simultaneously combine video with data graphs for more powerful analysis.

- PASCO Capstone is data collection and analysis software that has a special built-in compliance calibration routine for the Materials Tester.
- It is shown here plotting a graph and recording a video that are synced together in real time. Data analysis tools such as curve fits and area under the curve are available.
- Discover the powerful capabilities of PASCO Capstone by pairing it with any of our interfaces and 80+ sensors.



Enhance student understanding of the behavior of materials. PASCO Capstone software has the ability to embed live video from a webcam and sync the Materials Tester data to the recorded video. Then you can play back the video along with the data on the graph, stepping through one frame at a time to see the exact breaking point.

Order Information

PASCO Capstone Site LicenseUI-5400
PASCO Capstone Student License
(APP Store/Microsoft Store)

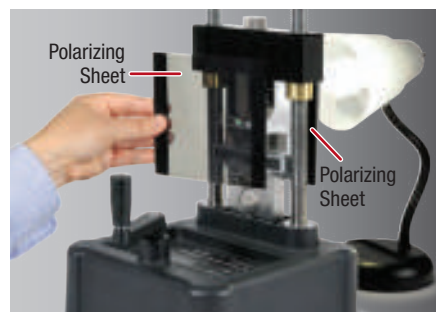
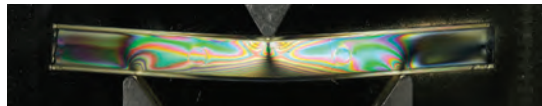
Download a free 30-day trial at www.pasco.com/capstone
macOS or Windows®

Materials Testing Accessories

Photoelasticity Accessory

ME-8241

See stress lines by bending a clear, colorless photoelastic I-Beam between two polarizing sheets. As the beam is bent, areas of greater stress show up as patterns of colored lines.



Photoelasticity Accessory consists of two crossed polarizing sheets that are placed in front of and behind the clear beam. When illuminated from behind by a bright white light, fringes due to the stress lines become visible.

Lamp not included.

Includes:

- One Photoelastic I-Beam Set: ME-7011
- Two polarizing sheets, 5 3/8" x 5 3/8" x 1/8"

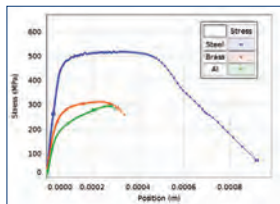
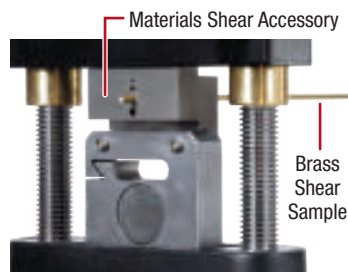
Order Information

Photoelasticity Accessory ME-8241
 Photoelastic I-Beam Set ME-7011
 Shown in use with:
 Bending Accessory ME-8237

Shear Accessory

ME-8239

Perform shear tests for a variety of wires. Accessory accepts diameters of 1/16", 3/32", 1/8", and 5/32". The Shear Accessory includes the ME-8240 Shear Samples, three each of 1/8" diameter, 12" long, aluminum, brass and mild steel.



The graph shows shearing of steel, brass, and aluminum rods, all having an 1/8" diameter. The shear strength of each material is measured.

Includes:

- Shearing Block and Shear Samples (ME-8240)
- 3 Each of three types of wire

Order Information

Shear Accessory ME-8239
 Replacement Supplies:
 Shear Samples ME-8240

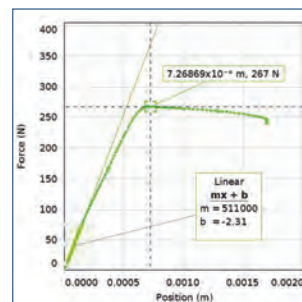
Structures Beam Fixture

ME-8242

The Structures Beam Fixture allows any of the I-Beams from PASCO's Structures System to be stretched or compressed in the Materials Testing Machine.

Includes:

- Clamps (2)



Find the critical load that causes the beam to buckle.



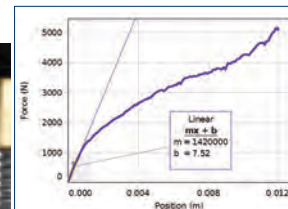
Order Information

Structures Beam Fixture ME-8242

Compression Accessory

ME-8247

This one-inch diameter platform provides a sturdy base to investigate compression of a variety of materials. It is shown here in a compression test on one of the included polyethylene test samples.



Before and after photo of compression sample



Includes:

- Platform
- 20 Polyethylene cylinders (ME-8248), 1.3 cm dia. x 2 cm long



Order Information

Compression Accessory ME-8247
 Replacement Supplies:
 Compression Samples ME-8248

Materials System Storage Base

ME-8229

The plastic base is made of High Density Polyethylene (HDPE). Includes base and mounting hardware.



Order Information

Materials System Storage Base ME-8229

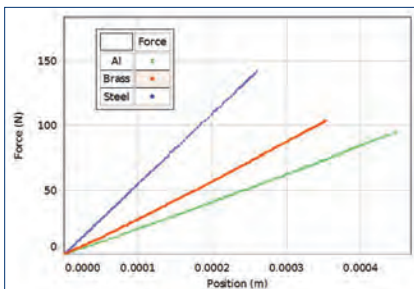
Bending Accessory

ME-8237

Perform three-point bending tests of various materials, including beams from the PASCO Structures System. Support anvils have adjustable separation up to 10 cm.



A Three-Point Bend Test is performed on a brass rod from the ME-8240 Shear Samples. The support anvils have adjustable separation up to 10 cm.



This Force vs. Position graph shows three-point bending for aluminum, brass, and steel samples, all with the same anvil spacing. From this graph, the flexural elastic modulus for each material is measured.

Four-Point Load Anvil

ME-8249

Add the optional Four-Point Bending Accessory to the ME-8237 to perform both three-point and four-point bending.

Perform a Four-Point Bend Test on the Cast Beams from the PASCO Structures System. Quantities measured include the Flexural Elastic Modulus and the Modulus of Rupture for the material.



ME-8249 Includes:

- A two-point fixture that, when added to the Bending Accessory, allows four-point bending.



ME-8237 Includes:

- Base
- Adjustable support anvil
- Load anvil



Order Information

Bending Accessory	ME-8237
Four-Point Load Anvil	ME-8249

Shown in use with:

Shear Samples	ME-8240
Thin I-Beams	ME-7012
Cast Beam Spares Set	ME-6983
(includes 30 rebar members)	

Flat Coupon Fixture

ME-8238

Test any flat material, such as paper, foil, or plastic. Shown using the Flat Plastic Test Coupons (AP-8222).

Includes:

- Clamps (2)
- Wrench



Order Information

Flat Coupon Fixture	ME-8238
Stress Strain Apparatus Coupons (40) - Plastic	AP-8222 p. 179
Stress Strain Apparatus Coupons (40) - Metal	AP-8223 p. 179

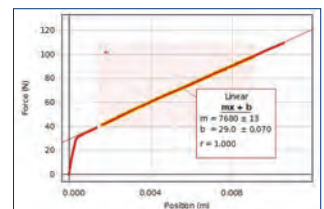
Clevis Grip

ME-8245

This generic pin and clevis adapter allows the user to tensile test a wide variety of samples with hooked ends or through-holes. It is shown here testing an extension spring (not included).

Includes:

- Clevis adapter and pin. Pin diameter is 0.187 in. Max width of sample is 0.300 in.



Order Information

Clevis Grip	ME-8245
-------------------	---------

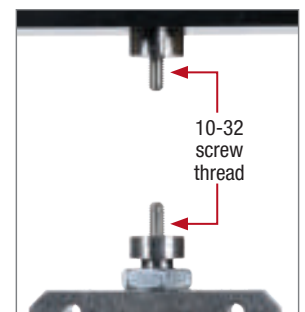
10-32 Adapter

ME-8246

Allows use of grips and attachments from other vendors that require a 10-32 male thread.

Includes:

- Upper and lower adapters



Order Information

10-32 Adapter	ME-8246
---------------------	---------

Materials

Stress-Strain Apparatus without Sensors

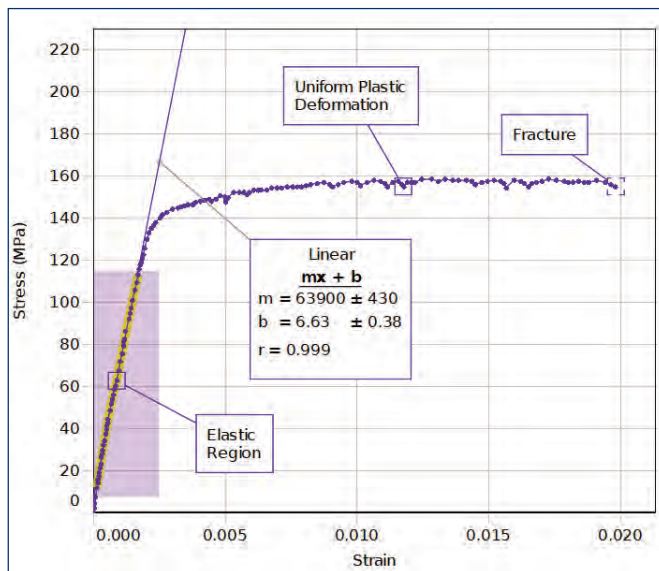
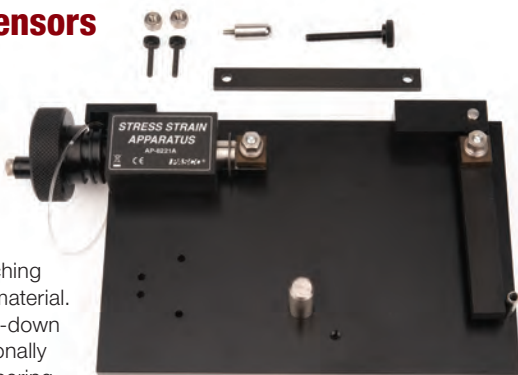
AP-8221A

This compact Stress-Strain Apparatus shows the stress and strain during the entire process of stretching and breaking a material. It offers a scaled-down version of traditionally expensive engineering devices, allowing students to explore all the same physics concepts without the high cost of a materials testing machine.

Since the Stress-Strain Apparatus shows the entire stress versus strain curve, it is possible to measure a wide range of material properties including:

- Young's Modulus
- Yield strength
- Tensile strength
- Ductility
- Toughness

Students can also compare the different curve shapes produced by various materials. PASCO Capstone software allows students to determine Young's Modulus by measuring the slope of the initial straight line (the elastic region) and to determine the toughness by integrating under the curve.



Specifications:

Maximum Force: 250 N

Includes:

- Stress/Strain Apparatus

Order Information

Stress-Strain Apparatus without Sensors AP-8221A

Stress-Strain Apparatus with PASPORT Sensors

AP-8213C



Includes:

- Stress/Strain Apparatus
- PASPORT High Resolution Force Sensor PS-2189
- PASPORT Rotary Motion Sensor PS-2120A
- Stress-Strain Apparatus Coupons, Plastic AP-8222
- Stress-Strain Apparatus Coupons, Metal AP-8223

Order Information

Stress-Strain Apparatus with PASPORT Sensors..... AP-8213C

Stress-Strain with Wireless Sensors

AP-8214B



Includes:

- Stress/Strain Apparatus
- Wireless Force Acceleration Sensor PS-3202
- Wireless Rotary Motion Sensor PS-3220
- Stress-Strain Apparatus Coupons, Plastic AP-8222
- Stress-Strain Apparatus Coupons, Metal AP-8223

Order Information

Stress-Strain with Wireless Sensors..... AP-8214B

Plastic Test Coupons

AP-8222



Comprised of a set of plastic coupons for use with PASCO's Stress/Strain Apparatus. Four types of color-coded samples, 10 pieces per sample:

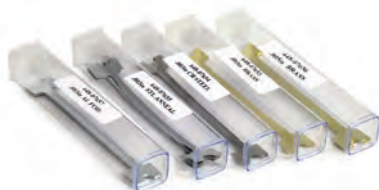
- High impact polystyrene (HIPS)
- Nylon 6 (15% glass fiber reinforced)
- Acrylonitrile butadiene styrene (ABS)
- Polypropylene (PP)

Order Information

Stress Strain Apparatus
Coupons – Plastic AP-8222

Metal Test Coupons

AP-8223



Set of metal test coupons of varying strengths, designed for use with PASCO's Stress Strain Apparatus. Five types of samples, 10 pieces per sample (sample containers labeled with thickness in inches)

- Brass (thin) 0.003"
- Brass (thick) 0.005"
- Cold-rolled steel 0.003"
- Aluminum 0.003"
- Annealed steel 0.003"

Order Information

Stress Strain Apparatus
Coupons – Metal AP-8223

Super-Flex I-Beam

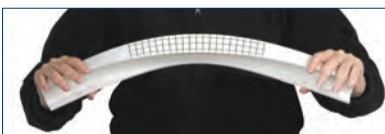
ME-8987

- ▶ Demonstrate the difference in stiffness between the two directions of bending
- ▶ Show that I-beams twist easily
- ▶ Show torsion and buckling
- ▶ Grid shows deformation

This Super-Flex I-Beam is made of plastic, so it can be visibly bent by hand. It shows the basic reasons for using this cross-section in construction. It is four times as stiff in the upright orientation as it is sideways.



Column buckling



Demonstrate lack of torsional strength.

Includes:

- Super-Flex I-Beam (24 inches long, 2 inches high)
- Instructions



Order Information

Super-Flex I-Beam ME-8987

Matter Model

ME-9825A

The atoms of the Matter Model are brightly colored spheres with the bonds between the atoms modeled by springs, so that when forces are applied, the atoms can move in response.



Demonstrate the normal force response as a material is compressed.



Includes:

- Atoms (4.5 g each) (40)
- Heavy, light and long springs (60)
- Nuts (to increase the atom mass) (30)
- 90 cm brass rod (for longitudinal waves)



The Matter Model is shipped in component pieces, ready for assembly.

Order Information

Matter Model ME-9825A

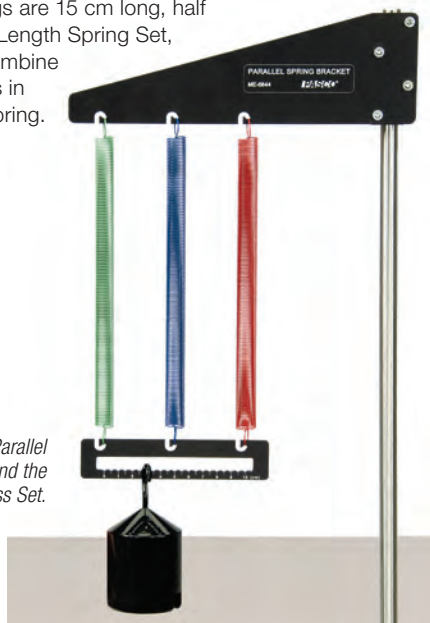
Springs & Oscillations

Series/Parallel Springs

ME-6842

This set of springs includes six springs with three different spring constants. These springs are 15 cm long, half the length of the Equal-Length Spring Set, making it possible to combine two series short springs in parallel with one long spring.

Shown in use with the Parallel Spring Bracket and the Hooked Mass Set.



Specifications:

The six color-coded springs, two of each color, have different spring constants: 10 N/m, 20 N/m, 40 N/m ($\pm 5\%$)

Includes:

- White storage box
- Six (color-coded) springs 15 cm long



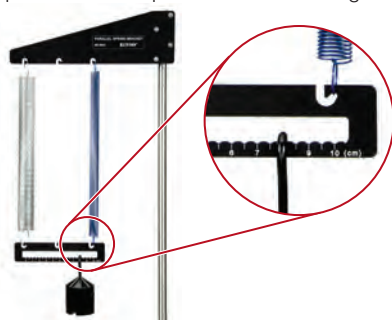
Order Information

Series/Parallel Springs.....	ME-6842	
Recommended:		
Hooked Mass Set.....	SE-8759	p. 215

Parallel Spring Bracket

ME-6844

This unique bracket allows springs of different spring constants to be hung in series and parallel. The masses can be hung in an offset position to compensate for the stronger spring.



Includes:

- Suspension bracket
- Parallel hook bar

Order Information

Parallel Spring Bracket.....	ME-6844
------------------------------	---------

Equal Length Spring Set

ME-8970

The five color-coded equal-length springs in this set have different spring constants: 25 N/m, 30 N/m, 35 N/m, 40 N/m, 50 N/m ($\pm 5\%$).



The five color-coded springs stretch different amounts when a 1 kg mass is hung from each spring.

These springs appear to be the same except for their colors. But, when equal masses are hung on them, each stretches a different amount. These extension springs are made of steel and are closed, requiring a slight initial force to separate the coils. The unstretched length of each spring is 30 cm and the approximate diameter is 1.4 cm. These springs are supplied with a white storage box with cardboard separators to keep the springs from touching each other.



Includes:

- White storage box
- Five (color-coded) springs 30 cm long

Order Information

Equal Length Spring Set.....	ME-8970	
Recommended:		
Pendulum Clamp	ME-9506	p. 206
Hooked Mass Set.....	SE-8759	p. 215

Demonstration Spring Set

ME-9866



This set includes four large springs for the demonstration of Hooke's Law or Conservation of Energy. Each spring is constructed of rugged spring steel with large loops that hang from a pendulum clamp or stretch with hanging masses. Spring constants range from 4 N/m to 14 N/m. Spring lengths vary between 11 cm and 22 cm.

Order Information

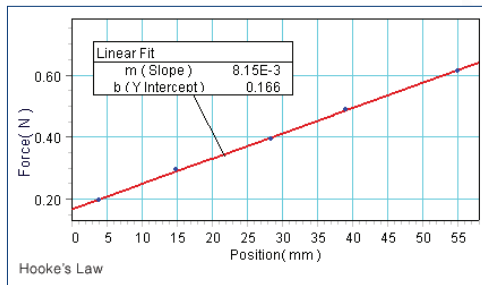
Demonstration Spring Set.....	ME-9866	
Recommended:		
Pendulum Clamp	ME-9506	p. 206
Hooked Mass Set.....	SE-8759	p. 215

Hooke's Law Set

ME-9827

- ▶ Brightly colored stretch indicator
- ▶ Transparent measuring scale
- ▶ Compatible with PASCO mass sets

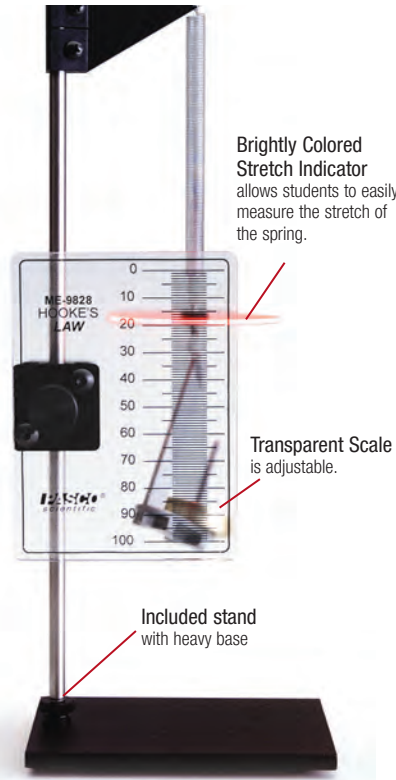
The Hooke's Law Set allows students to investigate the relationship between the force applied to a spring and the amount of stretch on the spring. This rugged set features a heavy base, so you can stretch the springs without toppling the unit. The transparent scale can be moved vertically to align zero with the brightly colored stretch indicator.



As a force is applied to the spring by placing mass on the hanger, the spring stretches. Students can graph the Applied Force vs. Spring Stretch. The slope of this graph is the spring constant of the spring. The vertical intercept shows the initial force required to begin stretching the spring.

Includes:

- Stand with heavy base
- Transparent scale with mm resolution
- Horizontal support for spring
- Brightly colored stretch indicator
- Three springs with identical diameter and length, but different spring constants
- Three of each spring included, for a total of nine springs: spring constants are 5 N/m, 8 N/m, 70 N/m



Order Information

Hooke's Law Set..... ME-9827
 Recommended:
 Mass and Hanger Set..... ME-8979 p. 215

Hooke's Law Spring Set

SE-8749

Includes three springs with the same diameter and length, but different spring constants. Three of each type of spring are included, and the springs fit nicely on PASCO mass hangers. All springs are 55 mm long and 7 mm in diameter. Spring constants are 5 N/m, 8 N/m and 70 N/m.



Order Information

Hooke's Law Spring Set..... SE-8749

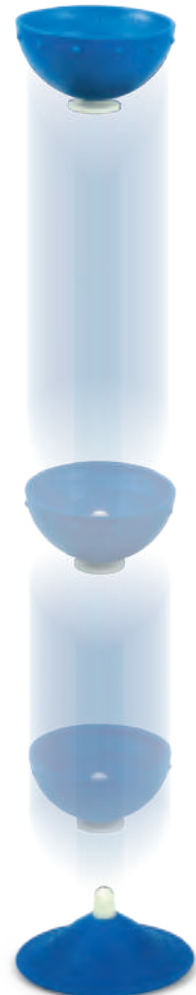
Dropper Popper

SE-7304

Invert this half rubber ball and drop it. It will bounce up higher than the release point. Discuss conservation of energy with your students.



There is a minimum height required to trigger the popper that can be related to barrier potentials.



Order Information

Dropper Popper SE-7304

Springs & Oscillations

Double-Length Slinky

SE-8760



The Slinky is an excellent tool for demonstrating transverse and longitudinal wave phenomena. This Double-Length Slinky is twice as long as a traditional Slinky, allowing students to create well-defined wave pulses and standing wave patterns. The tension in the Slinky is very low, causing wave pulses to travel slowly throughout its length.

Order Information

Double-Length Slinky..... SE-8760

Snakey

SE-7331



This extra-long metal spring is ideal for studying mechanical waves. The Snakey has an unstretched length of 2 meters. Pull the convenient end loops more than 10 meters apart to demonstrate transverse, longitudinal, and standing waves.

Order Information

Snakey SE-7331

Longitudinal Wave Spring

WA-9401



Using the Longitudinal Wave Spring accessory, it is easy to demonstrate and visualize the nodes and antinodes of longitudinal waves. Unstretched length is 13 cm.

Order Information

Longitudinal Wave Spring.....WA-9401

Photogate Pendulum Set

ME-8752

- Great for classic pendulum experiments

Cylindrical shape allows easy calculation of the speed of the pendulum using the time it blocks the photogate. Photogate not included.



The Photogate Pendulum Set is a unique set of four pendulums that have the same shape and size, but different masses. Due to their cylindrical shape, these pendulums are ideal for use in timing experiments with the photogate. One pendulum each of brass, plastic, wood, and aluminum is included.

Applications:

- Determine relationship between period and mass
- Determine relationship between period and amplitude
- Determine relationship between period and length

Includes:

- Brass pendulum
- Aluminum pendulum
- Plastic pendulum
- Wood pendulum



Order Information

Photogate Pendulum Set..... ME-8752

Harmonic Springs 8 pack

ME-9803B



Includes eight identical springs: 8 cm long, 3.4 N/M spring constant.

Order Information

Harmonic Springs 8 pack..... ME-9803B

IDS Spring Kit

ME-8999



Includes 12 springs (1.6 cm diameter) with approximate spring constants of: 3.4 N/m (3 short and 3 long springs) 6.8 N/m (3 short and 3 long springs)

Order Information

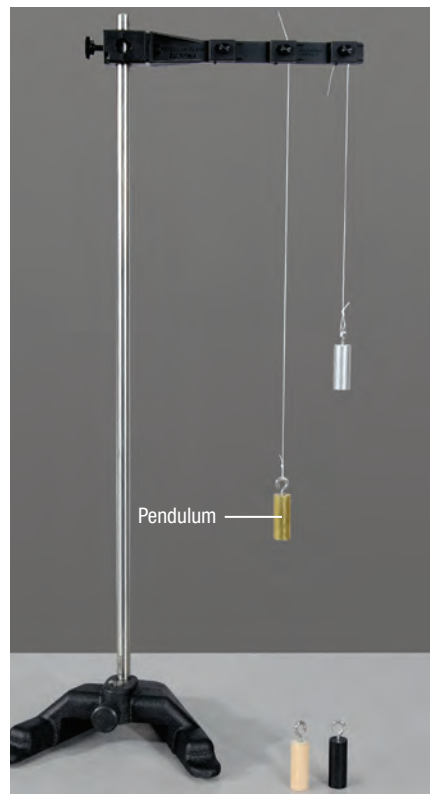
IDS Spring Kit ME-8999

Pendulum Clamp

ME-9506



Hang up to three springs or pendulums. Easily adjust the lengths of the pendulum strings.



See page 146 for more information.



Order Information

Pendulum ClampME-9506
Shown in use with:
Photogate
Pendulum SetME-8752
Small A-Base
with Leveling Feet.....ME-8989 p. 204
45 cm Stainless
Steel Rod.....ME-8736 p. 204

Bicycle Gyroscope

ME-6837

- ▶ Solid 1/2" steel shaft
- ▶ Cushioned hand-grips
- ▶ Precision ball bearings for low friction
- ▶ Non-marking rubber tire

The newly redesigned Bicycle Gyroscope is perfect for getting your students engaged in understanding rotational motion. Unlike other bicycle gyroscopes, the PASCO model is extremely rugged for years of use, but also lightweight at just 6 lbs. Cushioned hand-grips, a pull-cord with handle, and an included suspension cord (to demonstrate precession) make it simple and easy to use.

Precision ball bearings result in extremely low friction for both the Bicycle Gyroscope and the Rotating Chair.

Non-marking Rubber Tire



This 2.8 kg (6 lb.) Bicycle Gyroscope has a solid 2.7 mm (1/2") steel shaft with cushioned hand-grips.

Attach cord (included) to hole in handle to demonstrate precession.



Includes:

- Bicycle Gyroscope
- Cords with Handles (2)

Order Information

Bicycle Gyroscope..... ME-6837
Shown in use with:
Rotating Chair..... ME-6856



The Bicycle Gyroscope with the Rotating Chair gives you a perfect demonstration of the conservation of angular momentum.



Use the included pull-cord with handle to spin up the wheel.

Bicycle Wheel Mass Set

ME-6972

Adding all four of the masses adds 1.6 kg to the wheel's approximate 2.8 kg mass and increases its rotational inertia by over 60%.

Mass securely clamps to the wheel rim using included screws.



Includes:

- Four 400 g masses

Order Information

Bicycle Wheel Mass Set ME-6972
Shown in use with:
Bicycle Gyroscope..... ME-6837

Rotating Chair

ME-6856

Rugged design and incredibly low friction make this far superior to any office chair.

Sturdy 45 cm diameter rotating platform can be used with or without included chair.

Wrap rope around groove to apply torque.



Steel base

Includes:

- Chair
- Rotating Platform with Leveling Feet



Order Information

Rotating Chair..... ME-6856
Shown in use with:
Photogate Head ME-9498A

Gyroscope

Gyroscopic Motion

Demonstration Gyroscope (3-Axis)

ME-8960

- ▶ All components accessible
- ▶ Excellent demonstration tool
- ▶ Precision angle indicator

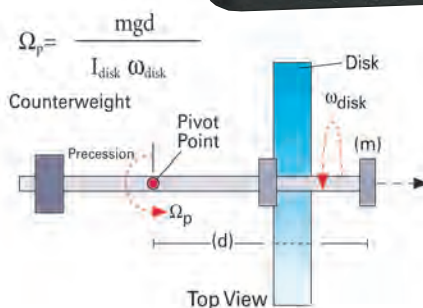
The low friction, open design of PASCO's Gyroscope enables rotational motion studies that were previously impossible with commercial units. The completely open design lets students stop precession by grabbing the vertical shaft, causing the Gyroscope to dip. Rotational mathematics can predict the dipping motion, but with PASCO's Gyroscope it can finally be confirmed.

How It Works:

The disk is spun by wrapping a string around the pulley and pulling. Or the disks can be spun by hand. Add mass to either end of the gyroscope and it responds with a predictable precession. Many features make this an exceptional demonstration tool for rotational motion concepts.

Features:

- ▶ **Low Friction:** 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.
- ▶ **Accurate Angle Indicator:** Measures from 30° to 140° and is easily read to the nearest degree. A retractable stop acts as a marker during experiments.
- ▶ **Easy Timing:** Low rotation speeds allow measurement of angular speed by counting revolutions and using a stopwatch.
- ▶ **Easy Balancing:** Two counterweights allow coarse and fine balance adjustment.
- ▶ **Large Inertia Disk:** With the large rotational inertia of the disk, PASCO's gyroscope generates precession rates similar to smaller, enclosed gyroscopes. The slow rotation speed of PASCO's disk lets students study fast as well as slow precession and use a stopwatch to make measurements.



Students can determine the rotational inertia of the rotating disk. They can then check the measured precession rate when a mass (m) is added a distance (d) from the pivot point.

Order Information

Demonstration Gyroscope
(3-Axis)..... ME-8960
Recommended:
Gyroscope Disk and Mass..... ME-8961



Accessory Disk
Add a second disk spinning in same or opposite directions.

A Unique Experiment: Rotate two disks in opposite directions at the same speed. The angular momenta cancel and the total angular momentum of the gyroscope is zero. The result is no precession.

Gyroscope Disk and Mass

ME-8961

Includes:

- Accessory Disk
- Extra Counter Mass

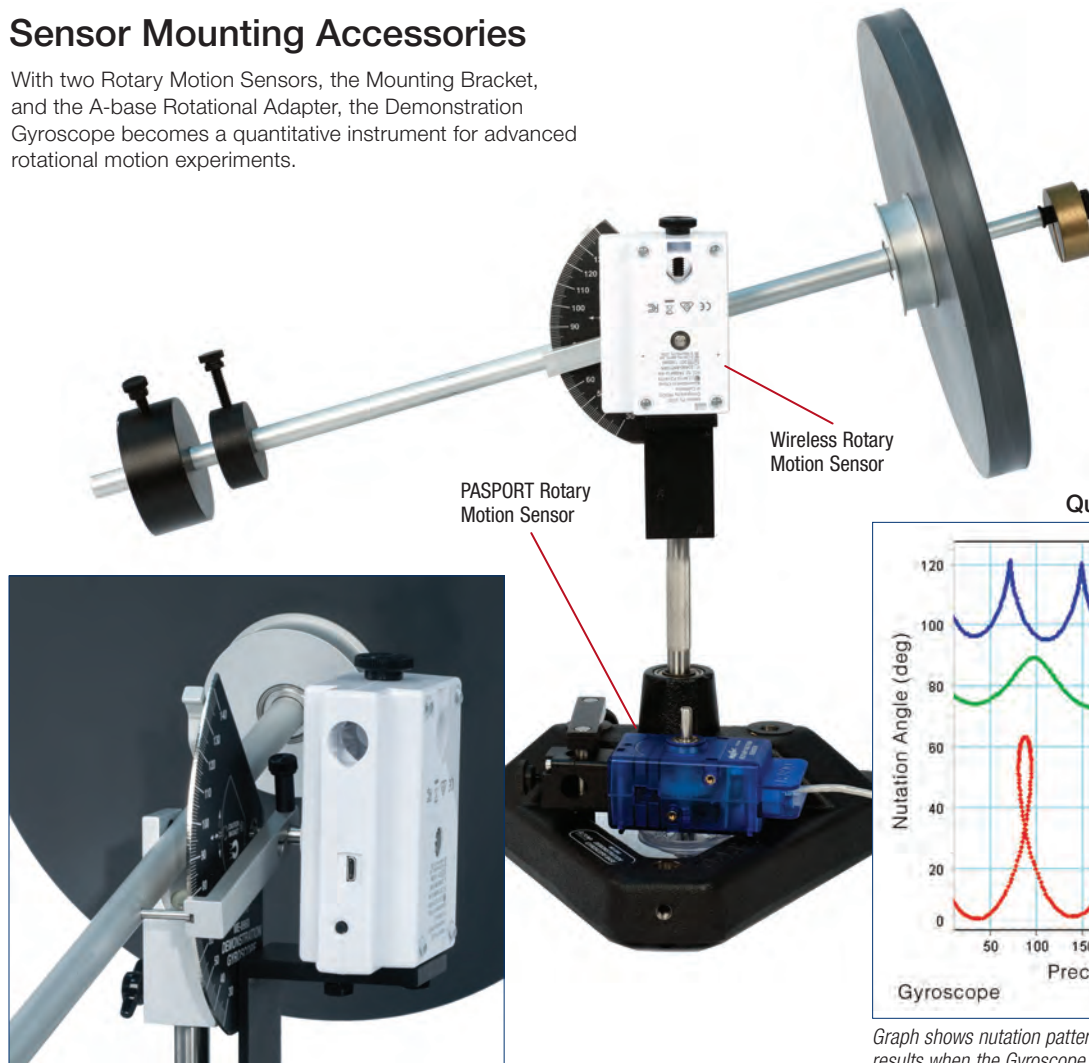
Order Information

Gyroscope Disk
and Mass.....ME-8961

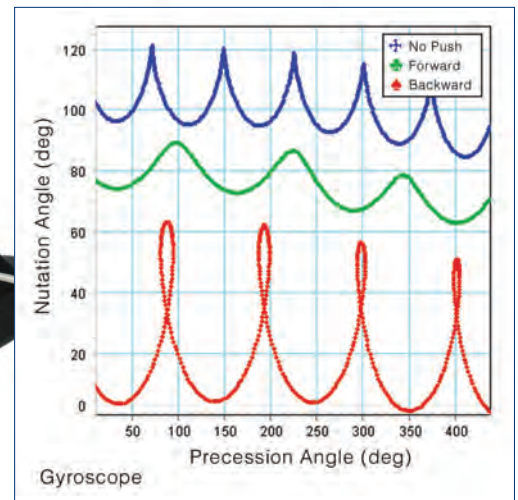


Sensor Mounting Accessories

With two Rotary Motion Sensors, the Mounting Bracket, and the A-base Rotational Adapter, the Demonstration Gyroscope becomes a quantitative instrument for advanced rotational motion experiments.



Quantitative Measurements



Graph shows nutation pattern for three cases: The blue trace results when the Gyroscope is released from rest, with no initial push forward or backward.

Gyroscope Mounting Bracket for Rotary Motion Sensor

ME-8963

With the Mounting Bracket and the A-base Rotational Adapter (CI-6690), the Demonstration Gyroscope becomes a quantitative instrument for advanced rotational motion experiments. With two Rotary Motion Sensors, students obtain a graphical picture of the Gyroscope's nutation and precession motions.



Order Information

For Recording Nutation Data:		
Gyroscope Mounting Bracket for Rotary Motion Sensor	ME-8963	
Required:		
PASPORT Rotary Motion Sensor	PS-2120A	p. 35
Interface		pp. 18-19
OR		
Wireless Rotary Motion Sensor	PS-3220	p. 53

A-Base Rotational Adapter

CI-6690

The A-base Adapter allows students to mount a Rotary Motion Sensor for high resolution data collection. One revolution of the vertical shaft corresponds to one revolution of the Rotary Motion Sensor, generating up to 4000 data points per revolution.

Includes:

- Rotary Motion Sensor Mounting Post
- O-Ring Drive Belt
- Three-Step Pulley
- Pulley Mounting Screw



This accessory is not compatible with PS-3220 Wireless Rotary Motion Sensor.

Order Information

For Recording Precession Data:		
A-Base Rotational Adapter	CI-6690	
Required:		
PASPORT Rotary Motion Sensor	PS-2120A	p. 35
Interface		pp. 18-19

Rotation

Complete Rotational System

ME-8950A

- Most versatile rotational system available
- Stable, 4 kg cast iron base
- Dual, low-friction ball bearings

The Complete Rotational System features a cast iron base, dual ball bearings, and stainless steel shaft. It generates moments of inertia large enough to be sensed by anyone rotating the system by hand. This system is ideal for experiments pertaining to centripetal force, angular momentum, and rotational motion. Angular velocity and motorized drive can be monitored using a computer.



Components of this system

1. Rotating aluminum platform with 4 kg cast iron base, dual ball bearings, stainless steel shaft, three-step pulley, two rectangular sliding 300 g masses, and 50 cm track where a number of accessories may be mounted.
2. The Rotational Inertia Accessory with a 22.9 cm diameter, 1.50 kg disk (which may be rotated on two axes), a 12.7 cm diameter, 1.42 kg ring and Super Pulley with support rod and adapter.
3. The Centripetal Force Accessory with spring support and radius indicator, mass support, three masses, and Super Pulley with Clamp.

Order Information

Complete Rotational System	ME-8950A	
Required:		
Mass and Hanger Set.....	ME-8979	p. 215

Interfacing Options

It is easy to use a computer to monitor rotational motion with the PASCO Rotational System. Here are two methods:

1. The **ME-9498A Photogate Head** mounts directly to the rotating platform base and measures angular speed. This works with the 850 and 550 Universal Interfaces.

NOTE: PASPORT interfaces require a Digital Adapter (PS-2109).



Order Information

Recommended:		
Photogate Head	ME-9498A	p. 27

2. The **CI-6538 or PS-2120 Rotary Motion Sensor** mounts to the base with an "A" Adapter and measures both angular speed and direction.



Order Information

Required for use with ScienceWorkshop:		
Rotary Motion Sensor	CI-6538	
Required for use with PASPORT:		
PASPORT Rotary Motion Sensor	PS-2120A	
A-Base Rotational Adapter	CI-6690	p. 189



Typical Experiments

- Centripetal Force
- Rotational Inertia of a Point Mass
- Rotational Inertia of a Disk Off-Axis (fixed and rotating)
- Rotational Inertia of Disk and Ring – Two Axes
- Conservation of Angular Momentum, Using a Point Mass
- Conservation of Angular Momentum, Using a Disk and Ring
- Conservation of Angular Momentum (Projectile Version)



To see the experiments, type the product number into the search box at www.pasco.com and download the manual.

Includes:

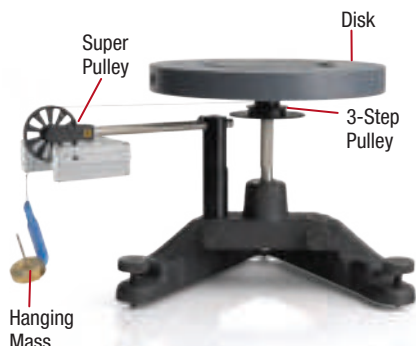
- Rotating Platform ME-8951
- Rotational Inertia Accessory ME-8953
- Centripetal Force Accessory ME-8952
- Instruction Manual

Experiments you can do with this rotational system:

Rotational Inertia of a Disk and Ring, 2 Axes

Center axis

With the disk mounted on the top of the vertical shaft, a torque is applied by a hanging mass. From the mass, radius, angular acceleration, and the rotational inertia of the disk can be determined.



Radial axis

The disk can also be mounted on edge to decrease the rotational inertia by half.



Rotational Inertia of Off-axis Disk

The Rotational Inertia Adapter allows students to mount the disk anywhere along the platform. A bearing mounted on one side of the disk allows it to act either as a rigid mass or as a mass free to rotate around its point of attachment as the platform turns on the vertical shaft.

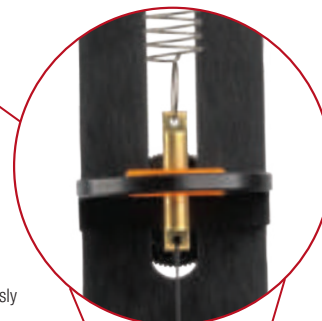


Centripetal Force

Centripetal force may be thoroughly investigated by varying both the mass and radius. The unique radius indicator allows students to continuously monitor the equilibrium position.

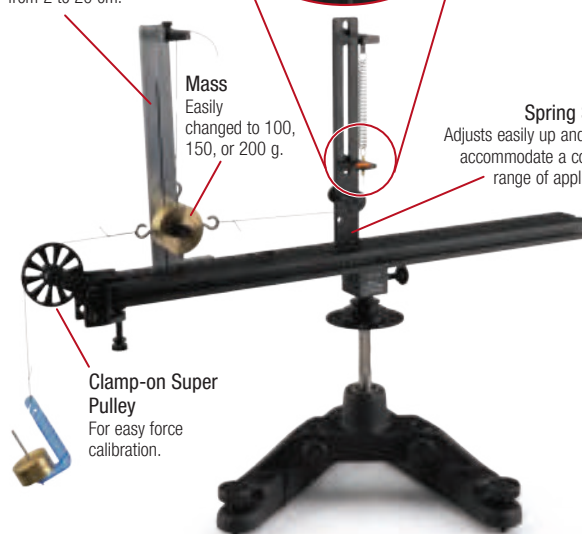
Accurate Radius Indicator
Can be monitored throughout the cycle of rotation.

Mass Support
Can be easily moved to change radius continuously from 2 to 20 cm.



Mass
Easily changed to 100, 150, or 200 g.

Spring Support
Adjusts easily up and down to accommodate a continuous range of applied force.



Clamp-on Super Pulley
For easy force calibration.

Conservation of Angular Momentum

Students can predict what will happen when a point mass rotating at a specific radius is pulled into a smaller radius. The rotational inertia of the mass at the inner and outer radii can be calculated and the results verified.



Rotational System Components and Accessories *see pages 188-189*

Rotating Platform and Rotational Inertia Accessory
p. 188



Centripetal Force Accessory
p. 188



Rotational Motor Drive
p. 189



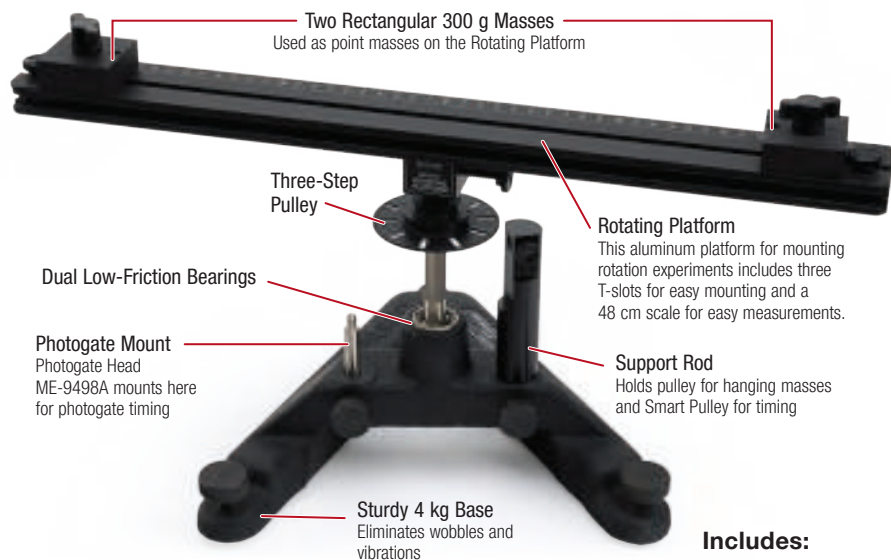
"A"-base Rotational Adapter
p. 189



Rotational System Components

Rotating Platform

ME-8951



The stable base and precision bearings of the Rotating Platform are the foundation of PASCO's Rotational System. It serves as an excellent base for general rotation experiments.

Order Information

Rotating Platform.....	ME-8951
Recommended:	
Rotational Inertia Accessory.....	ME-8953
Centripetal Force Accessory.....	ME-8952
Rotational Motor Drive	ME-8955

p. 189

Includes:

- Aluminum Platform for mounting rotation experiments
- 2 Rectangular 300 g Masses
- Sturdy 4 kg Cast Iron Base
- 3-step Pulley
- Support Rod

Rotational Inertia Accessory

ME-8953

A disk and a ring permit several experiments in rotational inertia. The disk may be rotated about several axes. When used in conjunction with the adapter, experiments using the parallel-axis theorem may be performed by moving the disk off from the center of rotation. The ball bearing on one side of the disk permits it to rotate freely for some experiments, while a "D" hole on the other side prevents rotation about the disk axis.

Includes:

- Heavy-Grade Plastic Disk (22.9 cm diameter, 1500 g)
- Metal Ring (12.7 cm outside diameter, 1420 g)
- Disk Adapter
- Super Pulley and Support Rod



Order Information

Rotational Inertia Accessory.....	ME-8953
-----------------------------------	---------

Centripetal Force Accessory

ME-8952

With traditional centripetal units, the ability to change the variables is either impossible or limited. The PASCO Centripetal Force Accessory is designed to make changing the mass, radius, or force quick and easy.



Features:

- **Vary Parameters Independently:** Change the centripetal force, mass and radius independently of each other.
- **Change Variables over a Wide Range:** Radius can be varied continuously from 2 to 20 cm, and the rotating mass can be 100, 150 or 200 g.
- **Observe the Radius Indicator throughout the Cycle:** PASCO's design has the indicator at the center of rotation, allowing continuous observation throughout the rotation cycle, resulting in more accurate measurements.



Includes:

- Spring Support and Radius Indicator Assembly
- Mass Support
- Masses (100 g and two 50 g)
- Super Pulley with Clamp

Order Information

Centripetal Force Accessory.....	ME-8952
----------------------------------	---------

Rotational Motor Drive

ME-8955

The Motor Drive is used with the Rotational Platform to power continuous rotational motion demonstrations. Use this motor to drive the Rotational Acceleration Tank at a constant speed. Power the Motor Drive with a ramp function using the DC Power Supply to smoothly increase the angular speed of the Centripetal Force Accessory. The motor requires a 12 V DC power supply or a function generator.



Easily change the gear ratio of the motor drive by moving the drive belt to one of the three possible pulley steps.

Specifications:

Motor: 12 V maximum, 0.2 A minimum

Base Spindle Speed Range: 10 to 600 rpm

Includes:

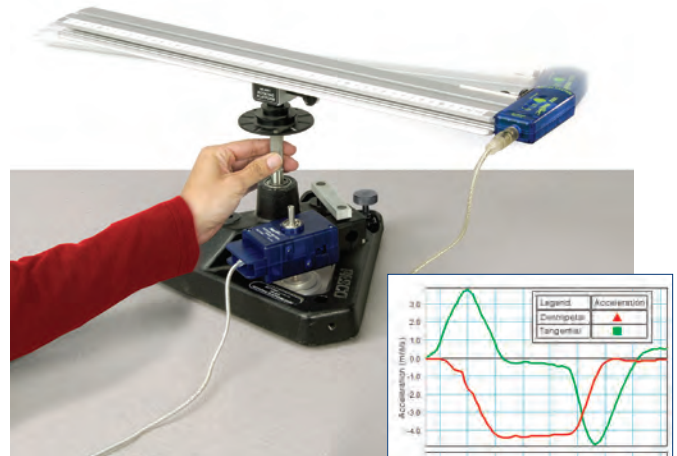
- Motor
- Three-Step Pulley
- Drive Belt



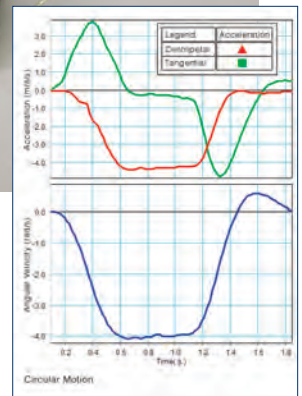
A-Base Rotational Adapter

CI-6690

The A-Base Adapter allows students to mount a Rotary Motion Sensor for high resolution data collection. One revolution of the vertical shaft corresponds to one revolution of the Rotary Motion Sensor, generating up to 4000 data points per revolution.



The platform is quickly rotated (from rest) and then brought to a stop. Both the tangential and centripetal acceleration is measured (using the 2-Axis Acceleration Sensor), while the platform's angular velocity is measured by the Rotary Motion Sensor.



Close-up of Rotary Motion Sensor mounted on "A"-Base



Includes:

- Rotary Motion Sensor Mounting Post
- O-Ring Drive Belt
- Three-Step Pulley
- Pulley Mounting Screw



Order Information

Rotational Motor Drive	ME-8955	
Required:		
Rotating Platform	ME-8951	p. 188
850 Universal Interface	UI-5000	p. 20
OR		
Function Generator	PI-8127	p. 274

Order Information

A-Base Rotational Adapter	CI-6690	
Required:		
Rotating Platform	ME-8951	p. 188
Rotary Motion Sensor	CI-6538	p. 26
OR		
PASPORT Rotary Motion Sensor	PS-2120A	p. 35

Centripetal Force

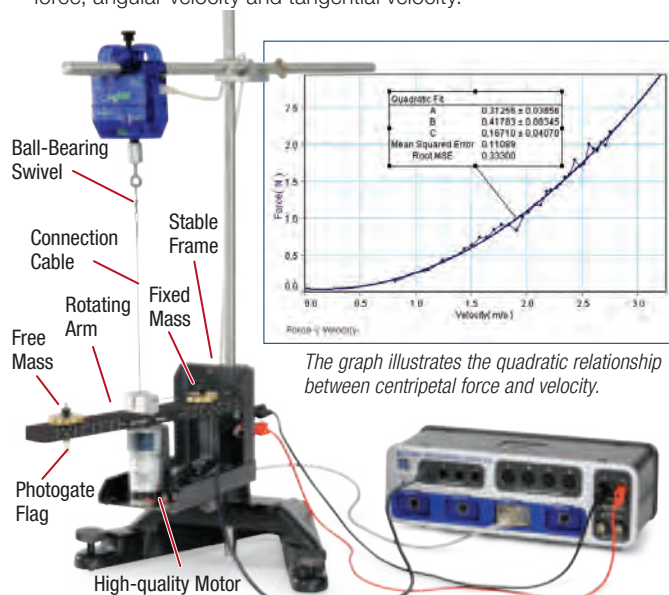
Centripetal Force Apparatus

ME-8088

- Empirically determine centripetal force
- Easy to set up
- Repeatable results

Features:

- **Stable Frame:** The metal frame can be easily attached to a ring stand using the included clamp. The frame may also be attached to a tabletop with a large table clamp.
- **High Quality Motor:** Will withstand years of student use.
- **Computer-based Measurements:** The Force Sensor and photogate facilitate accurate and repeatable measurements of force, angular velocity and tangential velocity.



The graph illustrates the quadratic relationship between centripetal force and velocity.

How It Works:

The rotating arm features a groove with two captured masses along its length. One of the masses is free to move along the length of the groove. The free mass is connected to a small cable that runs under a pulley in the center of the arm and up to a Force Sensor. A ball-bearing swivel is used to ensure the cable does not tangle as the arm rotates. The other mass is placed the same distance from the center as the free mass, thereby balancing the arm. A flag attached to the bottom of the fixed mass passes through the photogate once per revolution, allowing a calculation to be made of the angular and tangential velocity of the mass.

Includes:

- Frame with Mounted 12 VDC Electric Motor
- Connecting Cable
- Ball-Bearing Swivel
- Connecting Hardware for Photogate
- Mass Holder for Free Mass
- Mass Holder for Fixed Mass
- 5 g Mass (2)
- 10 g Mass (2)
- 20 g Mass (2)



Order Information

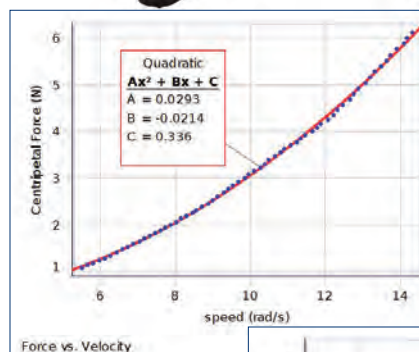
Centripetal Force Apparatus.....	ME-8088
Required:	
Force Sensor	p. 26, 36, 55
Photogate Head	p. 27
Triple Output Power Supply	SE-8587 p. 272
Large Rod Base	ME-8735 p. 204
45 cm Stainless Steel Rod	ME-8736 p. 204
120 cm Stainless Steel Rod	ME-8741 p. 204
Multi-Clamp	ME-9507 p. 206

Wireless Centripetal Force Accessory

ME-8094

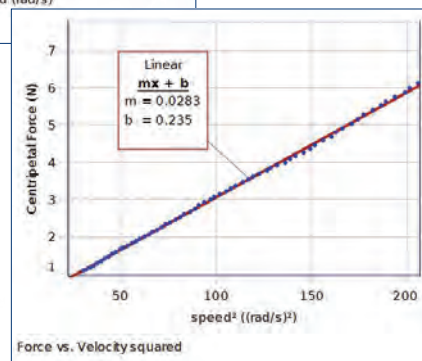
- Transmitting data wirelessly eliminates friction
- Uses Wireless Force Acceleration Sensor
- Vary speed, radius, and mass

The Wireless Centripetal Force Accessory is a low-friction, sliding mass holder that connects to a Wireless Force Acceleration Sensor (PS-3202). When installed on a Rotating Platform (ME-8951), it provides a simple and direct measurement of centripetal force and acceleration. Vary the mass using the holed masses in the Mass and Hanger Set (ME-8979). The string length is easily adjusted to vary the radius.



This PASCO Capstone graph shows the Centripetal Force (measured directly by the Wireless Force Acceleration Sensor) versus Angular Speed as the platform slows down.

In this PASCO Capstone graph, a "QuickCalc" of speed squared has been chosen on the horizontal axis, resulting in a straight line.



Includes:

- Low-friction sliding mass holder
- Mounting post for force sensor

Order Information

Wireless Centripetal Force Accessory.....	ME-8094
Recommended:	
Wireless Force Acceleration Sensor.....	PS-3202 p. 55
Mass and Hanger Set.....	ME-8979 p. 215
Rotating Platform.....	ME-8951 p. 188
PASCO Capstone.....	pp. 8-11

Handheld Centripetal Force Discover Centripetal Force Kit

ME-9837A



As the stopper is swung around in a circle by hand, the Force Sensor directly measures the centripetal force. This handheld method allows students to feel the centripetal force.

The Motion Sensor detects the stopper on each rotation and is used to calculate its speed.

Use this kit traditionally with hanging masses, or use it with a Force Sensor to continuously measure the centripetal force. Adding sensors to this classic experiment creates a dynamic, quantitative lab that your students will never forget.

Includes:

- Rubber Stoppers (sizes 6, 8, 10)
- Plastic Ties (10)
- Yellow String (73 meters)
- Hollow Tube



Order Information

Discover Centripetal Force Kit	ME-9837A	
Shown in use with:		
PASPORT High Resolution Force Sensor	PS-2189	p. 36
PASPORT Motion Sensor	PS-2103A	p. 34
Required for Classic Approach:		
Hooked Mass Set	SE-8759	p. 215
PASCO Stopwatch	ME-1234	p. 127

Flying Plane

SE-6673



An alternative to the Flying Pig, the Flying Plane is a great way to do experiments in uniform circular motion. The Flying Plane sweeps a conic section allowing students to measure the angle from the point of attachment and analyze the motion using force vector diagrams.

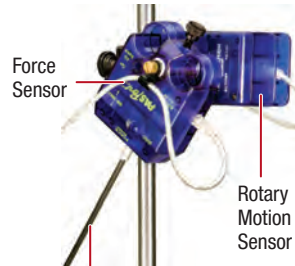
Order Information

Flying Plane	SE-6673
--------------------	---------

Centripetal Force Pendulum

ME-9821

- Quantitative force vs. velocity data
- Repeatable results
- Vary pendulum length and mass

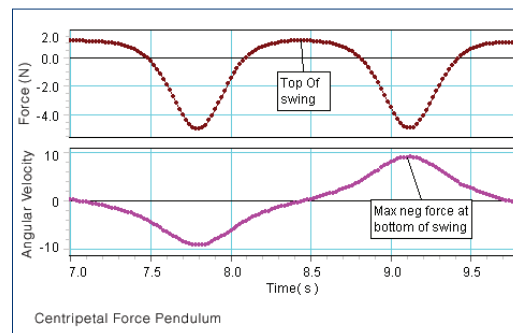


Very Low Mass
Rigid Graphite Tube



When used with Force and Rotary Motion Sensors, the Centripetal Force Pendulum allows students to collect accurate circular motion data.

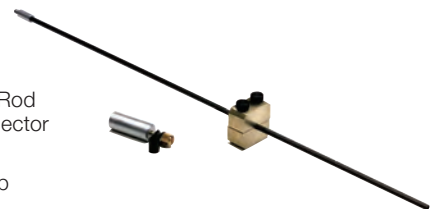
The Centripetal Force Pendulum attaches to a Force Sensor and allows students to directly measure the forces involved in circular motion. By attaching the Force Sensor/pendulum combination to the Rotary Motion Sensor, the relationship between force, mass, and velocity in a circular path can be investigated.



The Centripetal Force Pendulum is used to produce graphs of force and angular velocity vs. time. Note that the force changes direction at the top of the swing for large amplitudes.

Includes:

- Graphite Pendulum Rod with Threaded Connector
- Sliding Mass (100 g)
- Mount with Cord Clip



Order Information

Centripetal Force Pendulum	ME-9821	
Required:		
Large Rod Base	ME-8735	p. 204
45 cm Stainless Steel Rod	ME-8736	p. 204
90 cm Stainless Steel Rod	ME-8738	p. 204
Multi-Clamp	ME-9507	p. 206
PASPORT Rotary Motion Sensor	PS-2120A	p. 35
PASPORT Force Sensor	PS-2104	p. 36

Rotational Inertia

Rotational Inertia Set

ME-9774



Release two different sized objects simultaneously.



Compare rotational inertias of objects with different shapes and sizes. Students learn that the speed of an object rolling down the ramp is not affected by its mass or radius. The shape or distribution of the mass determines the outcome. The sphere will reach the bottom first, followed by the disk. The ring will be last.

Includes:

- 10 cm outer diameter set
 - Solid Sphere (810 g)
 - Ring (Aluminum, 230 g)
 - Disk (Plastic, 370 g)
- 5 cm outer diameter set
 - Solid Sphere (110 g)
 - Ring (Aluminum, 90 g)
 - Disk (Plastic, 70 g)
- Release Mechanism



Order Information

Rotational Inertia Set.....ME-9774

Spherical Mass Set

ME-8968



Hollow
Steel Ball

This set includes four balls, each of which has a diameter of 2.5 cm and a different mass than the others. Includes a hollow steel ball, solid steel ball, plastic ball and aluminum ball.

Applications:

- ▶ Race the hollow steel and solid aluminum balls down an incline. They have about the same mass, but the solid aluminum ball has a much larger acceleration down the ramp.
- ▶ Fire the yellow plastic, solid steel, and hollow steel balls from a PASCO Projectile Launcher.

Includes:

- Solid Yellow Nylon Ball (10 grams)
 - Solid Steel Ball (66 grams)
 - Hollow Steel Ball (21 grams)
 - Solid Aluminum Ball (24 grams)
- (release mechanism not included)



Order Information

Spherical Mass Set.....ME-8968

Rotational Inertia Wands

ME-9847

The red and blue wands have the same mass, but the red wand is easier to rotate because it has less rotational inertia.

These two wands have the same mass and the same dimensions and yet the red wand is easier to rotate. This is because the red wand has two metal slugs near its center, while the blue wand has two similar metal slugs at its ends. This demonstrates that rotational inertia depends on the distribution of the mass.

These sturdy plastic wands have small holes near the center and at the ends to enable students to see where the metal is located in each wand. What initially seems a mystery can be explained to the students by allowing them to examine the wands more closely.



To demonstrate the difference in rotational inertia of the two rods, ask two students to grab the center of a wand and instruct them to rotate the wand back and forth as rapidly as they can. No matter how strong the student with the blue wand is, he or she is not able to rotate it as fast as the student with the red wand.

Specifications:

Length: 1 m

Diameter: 4 cm

Ratio of Blue Rotational Inertia to Red: Approx. 6

Includes:

- Red Wand (1)
- Blue Wand (1)



Order Information

Rotational Inertia WandsME-9847

Pivot

ME-7034

Perform These Experiments:

- Meter Stick Torque
- Rotational Inertia
- Physical Pendulum
- Centripetal Acceleration

The Pivot is a general purpose rotation device that allows you to mount it on a rod stand to perform rotation experiments in the horizontal or vertical planes.

This Pivot can be used two ways:

- As a fulcrum in a meter stick torque balance: It can be mounted so the shaft is horizontal for use with the Meter Stick Torque to do torque experiments or to do pendulum experiments.
- As a rotation device for rotational inertia experiments: It can be clamped on a horizontal or vertical rod. It can also be mounted with the shaft vertical so it can be used as a rotational base for the Rotational Inertia Set (ME-3420).
- The Pivot has a 1/4-inch diameter shaft out both sides which rotates on two ball bearings. To record data, use with a Smart Gate (or any standard photogate) and pulley.

Features:

- Slotted shaft extends in two directions
- Built-in rod clamp for mounting horizontally or vertically
- 3-step pulley for applying torque
- Fits Rotary Motion Sensor accessories such as the Rotational Inertia Set (ME-3420)
- Ability to mount at any height



Pivot shown in use as a fulcrum in the Meter Stick Torque Set.

Specifications:

Slotted Shaft Diameter: 1/4-inch (6.35 mm)

Slotted Shaft Length: 16 mm (both sides)

Slotted Shaft: Both ends are threaded for the included 6-32 screw

Shielded Ball Bearings: 2

Case Dimensions: 4.0 x 4.1 x 7.3 cm

Built-in Rod Clamp:

Fits up to 1/2-inch (12.7 mm) diameter rod

Includes:

- Pivot
- 3-step Pulley



A Smart Gate with a Pulley measures the rotational velocity of the apparatus mounted on the Pivot.

Order Information

Pivot	ME-7034	
Recommended:		
Ring And Disk Set	ME-3419	p. 35
Super Pulley with Mounting Rod	ME-9499	p. 33
Wireless Smart Gate	PS-3225	p. 54

Pendulum Accessory

ME-8969

The pendulum rod and masses can be purchased separately.



Includes:

- 38 cm Pendulum Rod (27 g)
- 75 g Mass (2)

Order Information

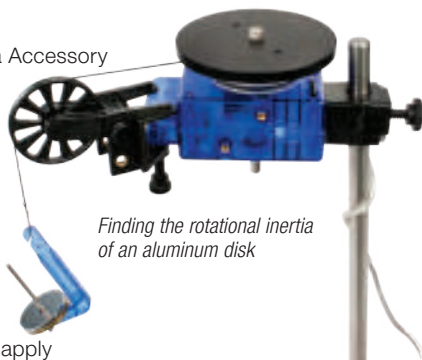
Pendulum Accessory	ME-8969
--------------------------	---------

Rotational Motion Accessories

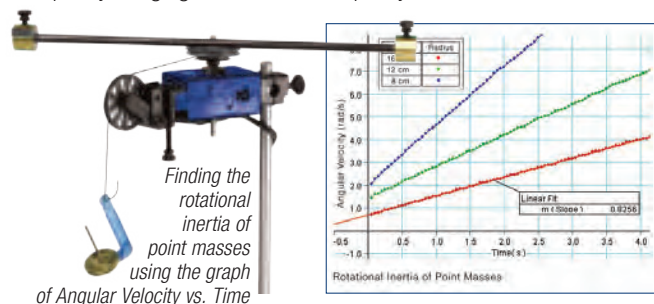
Rotational Inertia Accessory

ME-3420

Add the Rotational Inertia Accessory to any PASCO Rotary Motion Sensor to study the oscillations of a pendulum, the rotational inertia of a disk, a steel ring and a metal rod, as well as the conservation of momentum during a rotational collision. The clamp-on Super Pulley allows students to apply a torque by hanging a mass over the pulley.



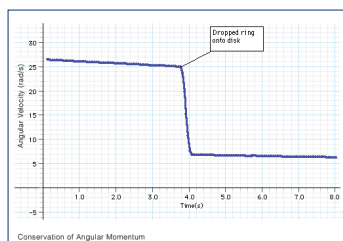
Finding the rotational inertia of an aluminum disk



Conservation of Angular Momentum

See page 353 for complete experiment.

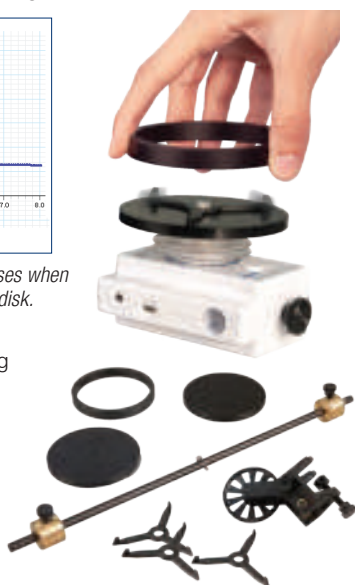
To demonstrate conservation of angular momentum, a non-rotating ring is dropped onto a rotating disk. The angular velocity of the disk is recorded in real time, and students can easily determine the angular velocities of the disk just before and after the ring is dropped. Combining these velocities with the rotational inertia of the disk and ring, students can confirm that angular momentum is conserved.



The angular speed of the disk decreases when the ring is dropped onto the spinning disk.

Includes:

- Disks: 8.9 cm diameter, 100 g
- Thin Ring: 8.9 cm o.d., 7.9 cm i.d., 100 g
- 38 cm Pendulum Rod (27 g)
- 75 g Mass (2)
- Clamp-on Super Pulley
- Alignment Guides: 3.9 cm radius, 1.7 g



Order Information

Rotational Inertia Accessory..... ME-3420
Also available:
Ring And Disk Set ME-3419
(Includes ring, 2 disks, and 3 alignment guides)

Rotational Motion Kit

ME-1260

At the heart of this kit is the Rotary Motion Sensor combined with the Rotational Inertia Accessory which enable eight rotational motion experiments to be performed. Basic concepts covered by this kit include the rotational inertia of a ring, disk, and point mass, torque and angular acceleration, and conservation of angular momentum.

More advanced concepts covered by this kit include rotational kinetic energy, period of a physical pendulum, and period of a large amplitude pendulum.

Perform These Experiments:

- ▶ Centripetal, Tangential, and Angular Acceleration
- ▶ Rotational Inertia
- ▶ Rotational Inertia of a Point Mass
- ▶ Newton's Second Law for Rotation
- ▶ Rotational Kinetic Energy
- ▶ Conservation of Angular Momentum
- ▶ Conservation of Energy of a Simple Pendulum
- ▶ Physical Pendulum
- ▶ Large Amplitude Pendulum



Includes:

- PASPORT Rotary Motion Sensor PS-2120A
- Rotational Inertia Accessory ME-3420
- Small A-Base with Leveling Feet ME-8989
- Stainless Steel Rod, 60 cm Threaded ME-8977
- Roll of Black Thread

Order Information

Rotational Motion Kit..... ME-1260
Required:
Mass and Hanger Set..... ME-8979
Recommended:
Ohaus Scout SKX Balance 420g..... SE-8756B

Rotational Motion and Torque Kit

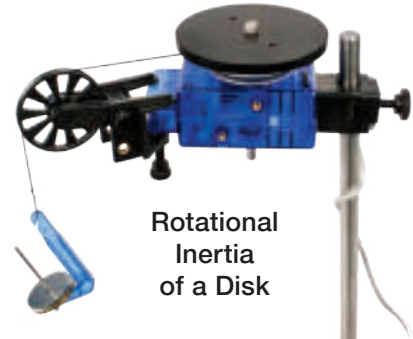
ME-1261

At the heart of this kit is the Rotary Motion Sensor combined with the Rotational Inertia Accessory which enable rotational motion experiments to be performed. Basic concepts covered by this kit include the rotational inertia of a ring, disk, and point mass, centripetal acceleration, torque and angular acceleration, and conservation of angular momentum.

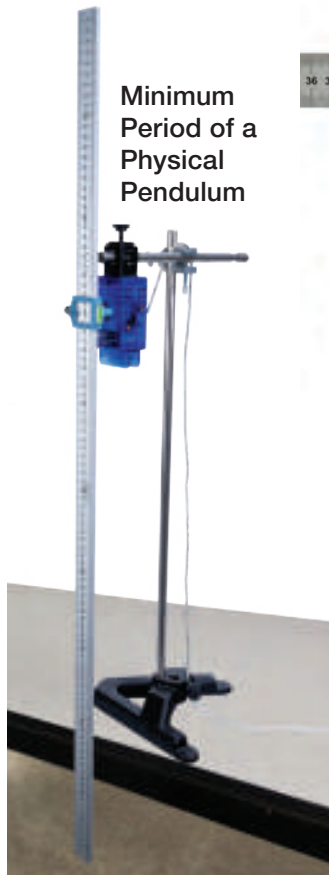
More advanced concepts covered by this kit include rotational kinetic energy, period of a physical pendulum, and period of a large amplitude pendulum.

The included Torsion Pendulum Accessory and Rotational Inertia Accessory are used on the Rotary Motion Sensor to find the period of a torsional pendulum.

This kit also has a meter stick and Meter Stick Torque Pivot Clamp and Mass Hangers which expand the capabilities of this kit to include static equilibrium as well as finding the pivot point that gives the minimum period of a thin rod pendulum.



**Rotational
Inertia
of a Disk**



**Minimum
Period of a
Physical
Pendulum**



**Meter Stick
Torque**

Perform These Experiments:

- ▶ Centripetal Acceleration
- ▶ Torsional Pendulum
- ▶ Static Equilibrium
- ▶ Rotational Inertia of a Thin Rod
- ▶ Minimum Period of a Physical Pendulum
- ▶ Centripetal, Tangential, and Angular Acceleration
- ▶ Newton's Second Law for Rotation
- ▶ Rotational Inertia
- ▶ Rotational Kinetic Energy
- ▶ Conservation of Angular Momentum
- ▶ Conservation of Energy of a Simple Pendulum
- ▶ Physical Pendulum
- ▶ Large Amplitude Pendulum



Torsional Pendulum

Includes:

- PASPORT Rotary Motion Sensor PS-2120A
- Ring And Disk Set ME-3419
- Torsional Pendulum ME-6694
- Meter Stick Torque Mass Hanger Set ME-7035
- Wireless Acceleration/Altimeter PS-3223
- Super Pulley with Clamp ME-9448B
- Small A-Base with Leveling Feet ME-8989
- Stainless Steel Rod, 60 cm Threaded ME-8977
- Aluminum Meter Stick
- Multi-Clamp ME-9507
- Round Base with Rod ME-8270
- Roll of Black Thread



Order Information

- Rotational Motion and Torque Kit..... ME-1261
- Required:
- Mass and Hanger Set..... ME-8979
- Recommended:
- Ohaus Scout SKX Balance 420g..... SE-8756B

Rotary Motion Sensor Accessories

Ball Catcher

ME-1252



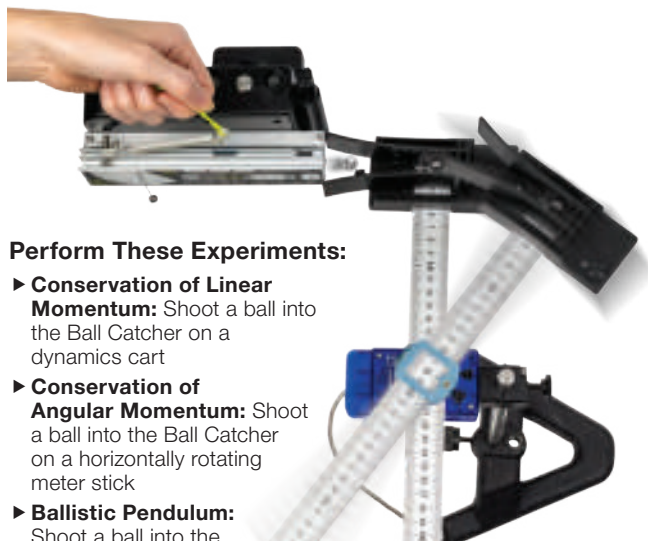
The Ball Catcher mounts on a dynamics cart or a rotating meter stick to catch a ball shot from a projectile launcher.

The Ball Catcher has adjustable sides to accommodate 1-inch balls from the Projectile Launcher (ME-6800) or 5/8-inch balls from the Mini Launcher (ME-6825B).

The Ball Catcher fits onto any PASCO dynamics cart or Smart Cart.

The Ball Catcher can also slide onto a PASCO Half-Meter Stick (ME-7044). When the half-meter stick is equipped with the meter stick clamp from the Meter Stick Torque Mass Hanger Set (ME-7035), the half-meter stick can be mounted on a rotary motion sensor to rotate in the horizontal plane when a ball is shot into the Ball Catcher.

The half-meter stick on a rotary motion sensor can also be oriented in the vertical plane to form a ballistic pendulum.



Perform These Experiments:

- **Conservation of Linear Momentum:** Shoot a ball into the Ball Catcher on a dynamics cart
- **Conservation of Angular Momentum:** Shoot a ball into the Ball Catcher on a horizontally rotating meter stick
- **Ballistic Pendulum:** Shoot a ball into the Ball Catcher on a meter stick pendulum

Includes:

- Ball Catcher
- Mounting screw

Order Information

Ball Catcher	ME-1252	
Shown in use with:		
Mini Launcher.....	ME-6825B	p. 137
PASPORT Rotary Motion Sensor	PS-2120A	p. 35
Half-Meter Stick	ME-7044	p. 208
Meter Stick Clamp from		
Meter Stick Torque Mass Hanger Set	ME-7035	p. 148

Torsional Pendulum

ME-6694

Concepts:

- Period of a torsional pendulum
- Rotational inertias of a disk, ring, and point masses
- Torque
- Torsional spring constant

The period of a Torsional Pendulum is measured and compared to the theoretical value. The torsional pendulum consists of a torsion wire attached to a Rotary Motion Sensor with an object (a disk, ring, or rod with point masses) mounted on top of it. The period of oscillation is measured from a plot of the angular displacement versus time. To calculate theoretical period, the rotational inertia is determined by measuring the dimensions of the object. The torsional spring constant is determined from the slope of a plot of force versus angular displacement.



Includes:

- Torsional Wires
(3 each of 3 different spring constants)
- Wire Clamps (2)

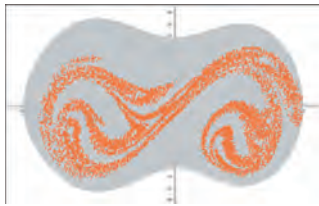
Order Information

Torsional Pendulum	ME-6694	
Required:		
Large Rod Base	ME-8735	p. 204
Stainless Steel Rod, 60 cm Threaded	ME-8977	p. 204
Rotational Inertia Accessory	ME-3420	p. 35
PASPORT Rotary Motion Sensor	PS-2120A	p. 35
PASPORT Force Sensor	PS-2104	p. 36
550 or 850 Universal Interface*		pp. 20-23
PASCO Capstone Software		pp. 8-11
* This experiment can be performed using the 550 or 850 Universal Interface or any PASPORT interface with two ports.		

Chaos/Driven Harmonic Accessory

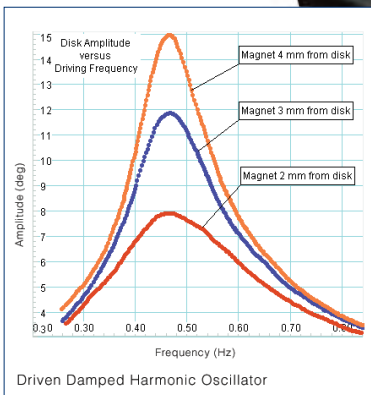
CI-6689A

The Chaos/Driven Harmonic Accessory allows students to study the behavior of a physical pendulum in either harmonic or chaotic motion. The disk mounts to a Rotary Motion Sensor, allowing PASCO Capstone™ to monitor and plot the pendulum's angular position and velocity.



Mechanical Oscillator/Driver
ME-8750

See full experiments:
EX-5522A Driven
Damped Harmonic
Oscillator on page 357
and EX-5523A Chaos
Experiment on page 356.

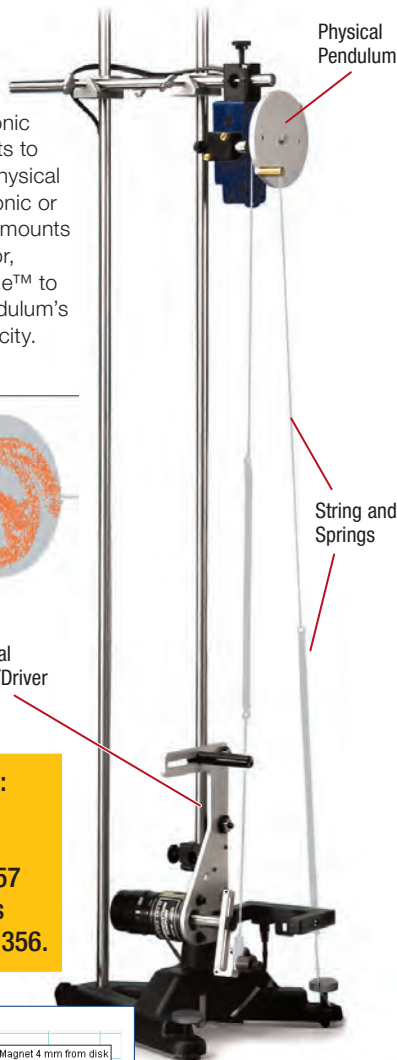


Includes:

- Rotating Disk (9.5 cm diameter, 120 g)
- Eccentric Mass (15 g)
- Springs
- Adjustable Magnet for Damping

Order Information

Chaos/Driven Harmonic Accessory..... CI-6689A



Angular Velocity vs.
Frequency graph shows
effects of magnetic
damping on amplitude of
resonance peak.



Physical Pendulum Set

ME-9833

This set of six objects is perfect for studying Physical Pendulums, Moments of Inertia, and the Parallel Axis Theorem. Each piece fastens directly to a Rotary Motion Sensor to measure the object's acceleration due to an applied torque, or the period when the pendulum freely oscillates.

Each piece is made from 1/4 inch-thick aluminum plate.

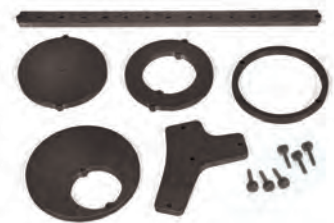


Unique design allows pivot exactly
at the edge. Measure the period
of the thick ring oscillating at
either the inner or outer radius.



Includes:

- Solid Disk
- Thick Ring
- Thin Ring
- Offset Hole
- Pendulum Bar
- Irregular Shape
- Mounting Screws (6)



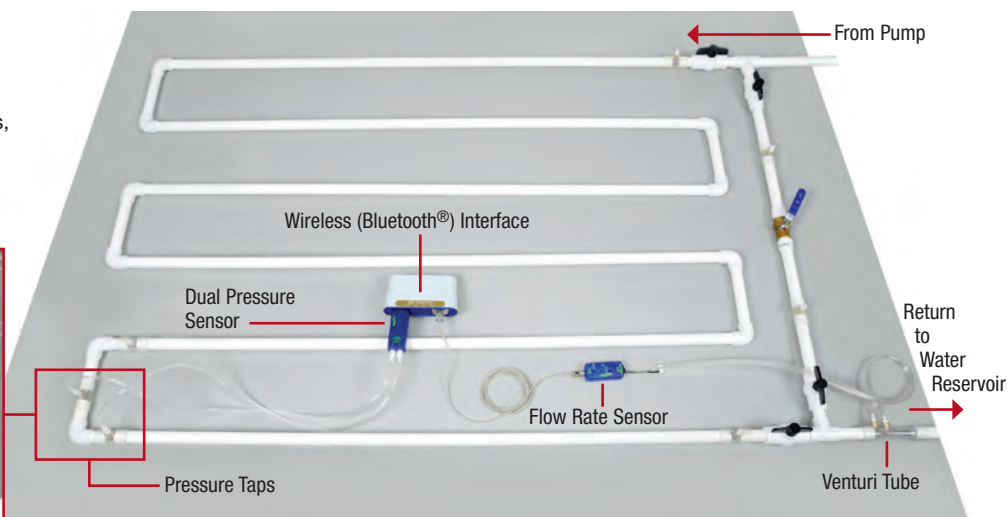
Order Information

Physical Pendulum Set..... ME-9833

Pipe Network

Pipe Network: Build it your way and instrument it inexpensively.

- ▶ Instrument your pipe network with pressure and flow sensors
- ▶ Transparent Venturi Tube and pressure taps
- ▶ Study head loss in pipes, fittings, and valves
- ▶ Find the relationship between pump head and flow rate



Measure Pressure

When constructing a pipe network, it is useful to know the pressure in the fluid at numerous places along the pipe. The transparent Pressure Taps can be glued into a 3/4" PVC pipe network at any place, using a slip joint. Each Pressure Tap has a quick-connect for a Dual Pressure Sensor (PS-2181). Since the quick-connect closes when disconnected, it is possible to move the pressure sensor around the network to determine the pressures at different positions, rather than having a separate pressure sensor for each position.

Measure Flow Rate

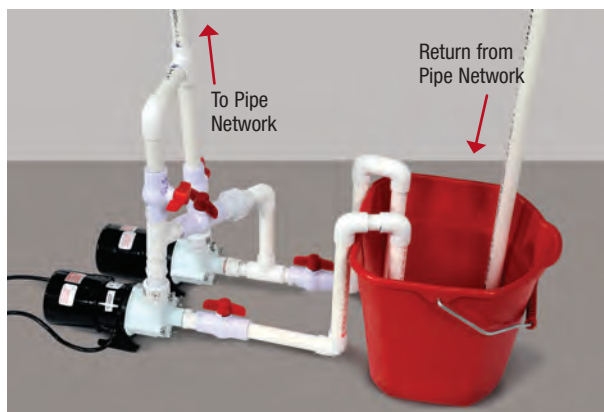
The General Flow Sensor measures the difference in fluid pressure between the two different cross-sectional areas, and the software does a calculation to convert this pressure difference into a velocity or volumetric flow rate. The Venturi Tube slip joints are designed to be glued into any 3/4" PVC pipe network. The Venturi Tube is made of clear PVC so the water can be seen flowing through it. It has a constriction and two pressure ports with tubing attached. The Venturi Tube is connected to the General Flow Sensor (PS-2225) by the matching couplers.

Create Pump Curves

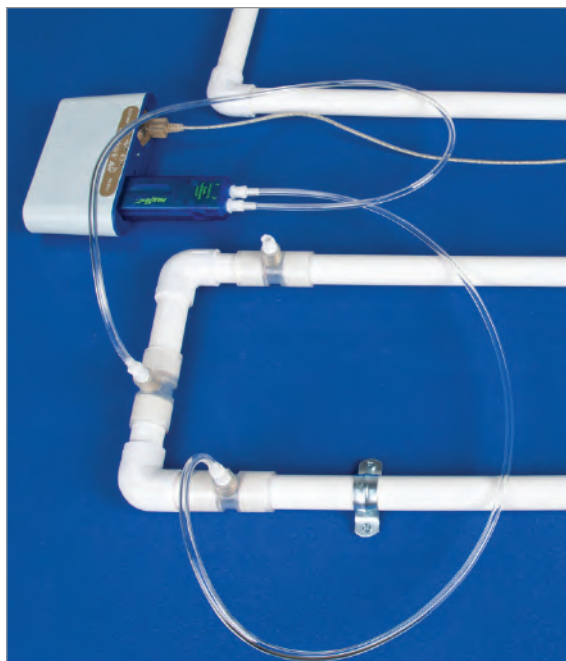
Create a plot of pressure vs. flow rate for a pump and determine the maximum head and flow rate. Study how these change when two pumps are connected in series or parallel.

Portable Interface

Use the SPARKlink Air (PS-2011) with a Dual Pressure Sensor (PS-2181) as a great portable pressure measurement system. The SPARKlink Air has two PASPORT sensor ports and can accommodate a General Flow Sensor to measure the volume flow rate and a Dual Pressure Sensor to measure the pressures along the pipe.



Study one pump or two pumps in series and parallel.



*Pressure Taps are installed before and after elbow joints to measure the pressure loss.
The Venturi Tube measures the velocity.*

General Flow Sensor

PS-2222



The General Flow Sensor determines the fluid velocity of air or water by measuring the difference in pressure between the two input tubes. The Venturi Tube or Pitot Tube must be connected to the General Flow Sensor to collect data. The type of fluid (air or water) being used is selected using PASCO software.

Order Information

General Flow Sensor PS-2222

PASPORT Dual Pressure Sensor

PS-2181

- Measure pressure at two pipe pressure taps at once



The Dual Pressure Sensor is capable of reading two absolute pressures, one gauge pressure, or one differential pressure. Dynamic variable over-sampling automatically reduces the measurement noise at low sampling rates. Sample rates up to 1000 Hz make studies of both transient and steady-state pressure possible. Includes quick-connect tubing.

Specifications:

Maximum Sample Rate: 1000 Hz

Absolute Pressure: 0 to 200 kPa, 0.01 kPa resolution at 10 Hz and 1 kPa repeatability (displays pressure in kPa, N/m², and psi)

Differential Pressure: ± 100 kPa, 0.01 kPa resolution at 10 Hz and 1 kPa repeatability (displays pressure in kPa, N/m², and psi)

Order Information

PASPORT Dual Pressure Sensor PS-2181

Order Information

Required for all above:
 PASPORT Interface pp. 18-19
 PASCO Capstone Software pp. 8-11
 PVC Pipe and Fittings (supplied by user)
 Pumps (2) (supplied by user)

Venturi Tube

ME-2220



The Venturi Tube is made of clear PVC, so the water can be seen flowing through it. It has a constriction and two pressure ports with tubing attached. The Venturi Tube is connected to the General Flow Sensor by the matching couplers.

The General Flow Sensor measures the difference in fluid pressure between the two different cross-sectional areas and the software does a calculation to convert this pressure difference into a velocity or volumetric flow rate. The Venturi Tube slip joints are designed to be glued into any 3/4" PVC pipe network.

Order Information

Venturi Tube ME-2220

Pressure Taps (set of 5)

ME-2224A



The transparent Pressure Taps can be glued into a 3/4" PVC pipe network at any place, using a slip joint.

Each Pressure Tap has a quick-connect for a Dual Pressure Sensor (PS-2181). Since the quick-connect closes when disconnected, it is possible to move the pressure sensor around the network to determine the pressures at different positions, rather than having a separate pressure sensor for each position.

Includes:

- Pressure Taps (5)
- 1/8" ID Tubing (4.5 m)
- Couplings (10)

Order Information

Pressure Taps (set of 5) ME-2224A

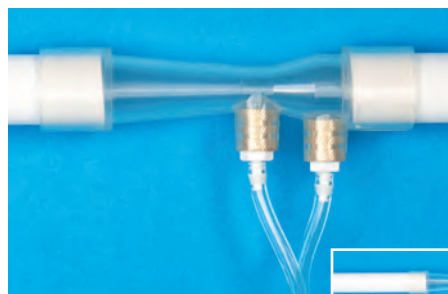
Fluids

Explore the Equations for Fluid Flow Using Sensors

General Flow Sensor with Venturi Tube

PS-2225

- Measure fluid velocities and confirm the Continuity Equation
- Use Bernoulli's Equation to determine pressure difference
- Show faster moving fluids have lower pressures



The Venturi Tube has pressure taps at the narrow diameter and the larger diameter.

The General Flow Sensor connects to the Venturi Tube to measure the pressures.



In this apparatus, the Venturi Tube has pressure taps at the narrow diameter and the larger diameter. The General Flow Sensor connects to the Venturi Tube to measure the different pressures due to different fluid velocities. You supply the 3/4 inch PVC pipe and the water. It is suggested that you connect the pipe to a faucet with flexible tubing and, at the other end, let the water flow into a bucket resting on a Force Platform (PS-2141). As the water flows, the velocity can be determined by the changing weight of the bucket as measured by the Force Platform.

The recommended interface is the SPARKlink Air because two ports are required and it is convenient to have a wireless interface so your laptop can be away from the water. However, two AirLinks (PS-3200) or a 550 or 850 Universal Interface will do as well.

Continuity Equation: $A_1 v_1 = A_2 v_2$

Bernoulli's Equation: $P_1 + \frac{1}{2}\rho v_1^2 = P_2 + \frac{1}{2}\rho v_2^2$
(at constant height)

Order Information

General Flow Sensor with Venturi Tube.....	PS-2225	
PASPORT Force Platform.....	PS-2141	p. 37
SPARKlink Air Interface	PS-2011	p. 50
PASCO Capstone Software		See pages 8-11
Supplied by User:		
PVC Pipe (3/4 inch), water, bucket		
Recommended (for velocity verification):		
Pitot Tube.....	ME-2221	p. 45

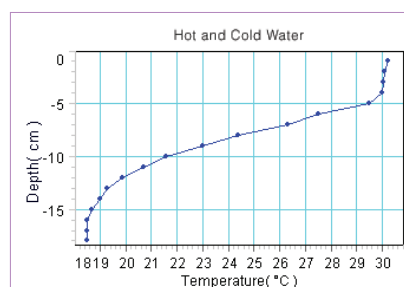
Density Circulation Model

ME-6816

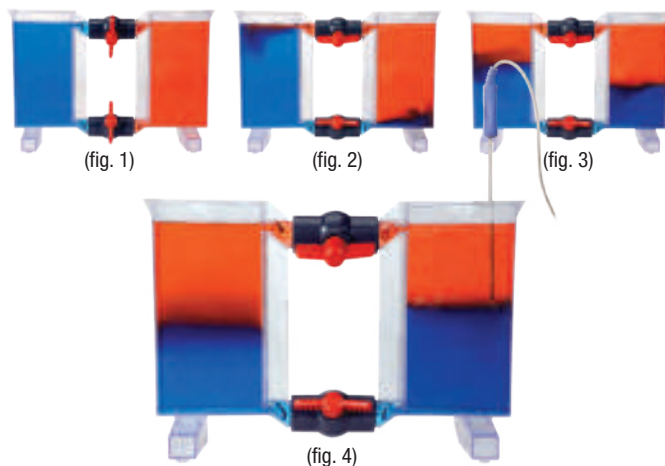
- Model density-driven circulation based on temperature, dissolved substances, or different liquids
- Demonstrate the driving forces of vertical ocean currents
- Measure temperature inversions based on density difference



The PASCO Density Circulation Model allows students to model, measure and understand the complex density-driven circulation associated with heat transfer through convection. Students can recreate vertical ocean currents driven by water bodies with density differences. They can extend this learning by using sensors to collect data and create graphs showing the thermocline, halocline and pycnocline using a Salinity Sensor PS-2195.



Here is data showing Temperature vs. Depth. Rapid temperature change occurs in the region where the two water bodies mix.



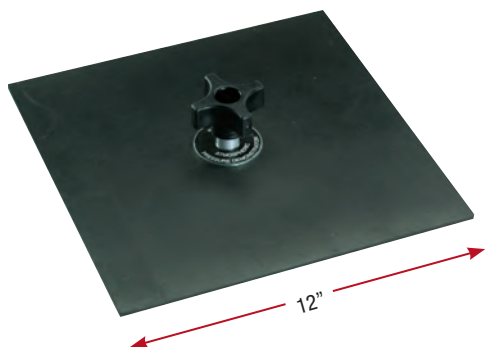
With the valves closed (fig. 1), two bodies of liquid can be created that differ in temperature, dissolved materials, or other properties. When the valves are opened, a smooth flow of liquid occurs between the chambers (fig. 2 and fig. 3). Minimal mixing occurs and results in clearly defined layers of liquid based on density (fig. 4).

Order Information

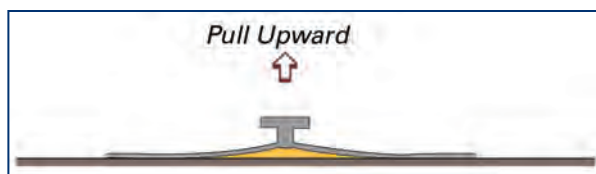
Density Circulation Model	ME-6816	
Show in use with:		
PASPORT Stainless Steel Temperature Probe	PS-2153	p. 40
Recommended:		
PASPORT Salinity Sensor	PS-2195	

Atmospheric Pressure Demonstrator

ME-8966A



Demonstrate the effect of a pressure differential. Easily lift a box or stool by simply placing the rubber sheet on a smooth surface of the object and lifting up on the handle.



As you pull up on the handle, a low-pressure region is created.



Order Information

Atmospheric Pressure Demonstrator.....ME-8966A

Air Cannon

SE-7370

The Air Cannon uses a vortex of air for ammunition. Its unique shape creates a stable toroidal vortex. Pull back the flexible membrane, release, and the invisible wave front of air can hit a target 20 feet away. Here is a great demonstration of the energy that can be stored in waves.



Order Information

Air Cannon.....SE-7370

PhiTOP

SE-7594

The PhiTOP is an egg-shaped top (a prolate ellipsoid) that can be spun by hand to stand up on end. This is a fascinating demonstration used by Nikola Tesla in 1893.

When spun with a magnetic stirrer, the PhiTOP replicates Tesla's famous Egg of Columbus demonstration. An alternating magnetic field will spin the PhiTOP from rest along its minor axis due to Lenz's law of electromagnetic induction. As the angular speed increases, the center of mass will rise, and the PhiTOP will spin along its major axis.

Includes:

- PhiTOP
- Mirror Stand



Order Information

PhiTOP.....SE-7594

Recommended:

Magnetic Stirrer.....SE-7700

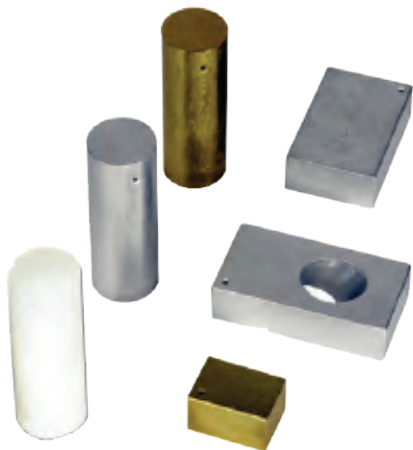
Density

Density Set

ME-8569A

See page 350
for Archimedes'
Principle Experiment.

Use this versatile set of materials with the Overflow Can to investigate Archimedes' Principle of displacement, specific heats, and basic length/volume relationships. Includes pieces that have the same shape, volume, density, and mass, so the variable of interest can readily be isolated. Each piece has a hole, so it can be suspended from a string.



Includes:

- Three cylinders: aluminum, brass, plastic; 2.2 cm dia. x 6.4 cm long (plastic is less dense than water)
- Two blocks: aluminum (1.9 x 3.2 x 4.1 cm) and brass (1.6 x 1.9 x 2.8 cm); The mass of each block equals that of the aluminum cylinder.
- One irregular shape: aluminum
- Instruction manual

Order Information

Density Set ME-8569A

Mole Set

SE-7586

The Mole Set contains four element specimens: Copper, Iron, Zinc and Aluminum. Each sample contains approximately one mole, 6.02×10^{23} atoms of the element.



Includes:

- Mole samples: Zinc, Aluminum, Iron, Copper
- Teaching Suggestions

Order Information

Mole Set SE-7586

Overflow Can

SE-8568A

This aluminum Overflow Can provides direct volume measurements for the materials supplied in the Density Set, as well as displacement measurements for buoyancy experiments. It has a 52 mm diameter, a usable volume of 185 cm³. Requires a graduated cylinder or a gram balance to measure the displaced volume.

Specifications:

Height: 10.2 cm

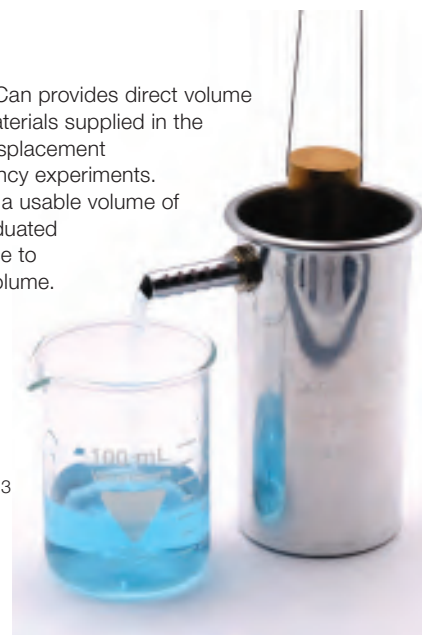
Spout Height: 8.7 cm

Inner Diameter: 5.2 cm

Usable Volume: 185 cm³

Includes:

- Can only



Order Information

Overflow Can SE-8568A

Glassware

Rugged borosilicate glassware for use in the physics lab.



Order Information

Beaker, 100 ml (12 pack) SE-7287

Beaker, 1000 ml (6 pack) SE-7288

50 ml Graduated Cylinder (12 pack) SE-7289

Super Pulley

ME-9450A

- ▶ 20 N max load
- ▶ Nearly frictionless
- ▶ Durable
- ▶ Precision dimensions



The PASCO Super Pulley is the standard in physics labs. Its low-friction design produces excellent results. The precision spacing of the 10 spokes makes it ideal for photogate monitoring with PASCO's computer interfaces and photogate systems.

Order Information

Super Pulley ME-9450A

Pulley Mounting Rod

SA-9242

This 14 cm long stainless steel mounting rod is 9.5 mm (3/8 in.) in diameter and fits most standard laboratory clamps, including the PASCO Universal Clamp. It has a standard 1/4"-20 thread.



Order Information

Pulley Mounting Rod
(rod only) SA-9242

Wireless Smart Pulley

PS-3704

The Wireless Smart Pulley attaches directly to the Wireless Smart Gate, providing a simple, low-friction system to measure position, velocity and acceleration. Remove the pulley to use the photogate in standard photogate experiments.



Includes:

- Wireless Smart Gate (1) PS-3225
- Super Pulley (1) ME-9450A
- Super Pulley Rod (1)

Order Information

Wireless Smart Pulley PS-3704

Super Pulley with Mounting Rod

ME-9499

This Super Pulley mounted on a rigid plastic mounting rod (12.7 mm diameter, 14 cm long) fits most standard laboratory clamps.



Order Information

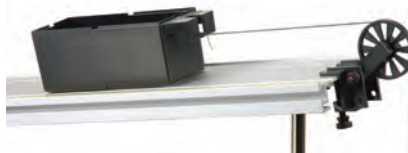
Super Pulley
With Mounting Rod ME-9499

Super Pulley with Clamp

ME-9448B



Upgrade your force table and inclined plane experiments. The Super Pulley with its integral clamp makes setup and alignment easy. The pulley height is fully adjustable, so you can skim the top of a force table for parallax-free readings. Yet you can keep the force parallel to the track on an inclined plane, as shown in the photo below. Fits tables up to 2.0 cm (13/16 in.) thick.



Order Information

Super Pulley with Clamp ME-9448B

Mounting Rods (10 pack)

ME-9483

These rigid plastic pulley handles (14 cm long, 1.27 mm diameter) screw into a Super Pulley.



Order Information

Mounting Rods (10 pack) ME-9483

Photogate/Pulley System

ME-6838A

The Super Pulley attaches directly to a Photogate Head, providing a simple, low-friction system to measure position, velocity and acceleration. Additionally, with the pulley removed, the photogate can be used to perform standard photogate experiments.



Order Information

Photogate & Pulley System ME-6838A

Atwood's Machine

SA-9241



Two Super Pulleys mounted on a 6.4 cm long rod produce a classic, low-friction introduction to Newton's Second Law. The instruction sheet fully describes both the experiment and the theory.

Includes:

- Two Pulleys
- Connecting Rod



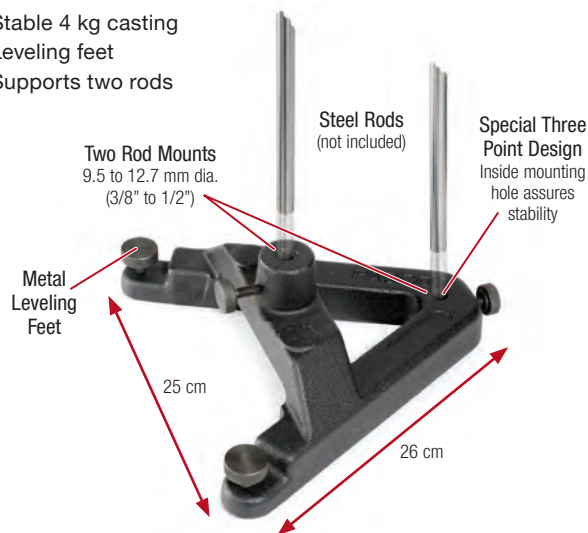
Atwood's Machine SA-9241

Lab Supplies

Large Rod Base

ME-8735

- Stable 4 kg casting
- Leveling feet
- Supports two rods



This sturdy 4 kg cast-iron wide base supports one or two rods. Rods from 9.5 to 12.7 mm (3/8 to 1/2 inches) diameter can be supported. Two adjustable feet provide the necessary leveling capabilities.

Order Information

Large Rod BaseME-8735

Metal Knobs and Feet (4 pack)

ME-8954

These replacement knobs and feet for the ME-8735 Large Rod Base are made of solid steel with knurled knobs and 5/16"-24 thread.



Order Information

Metal Knobs and Feet ME-8954

Small A-Base with Leveling Feet

ME-8989

This 1.8 kg cast iron base is smaller than the Large Rod Base (ME-8735). This base can be used with both threaded and nonthreaded rods. Non-threaded rods from 9.5 to 13 mm (3/8 to 1/2 inches) diameter can be supported. Threaded rods must be 12.7 mm (1/2 inch) in diameter with 1/2"-13 thread, such as the 60 cm rod (ME-8977). This base has two screw feet, allowing the supported apparatus to be leveled.



Order Information

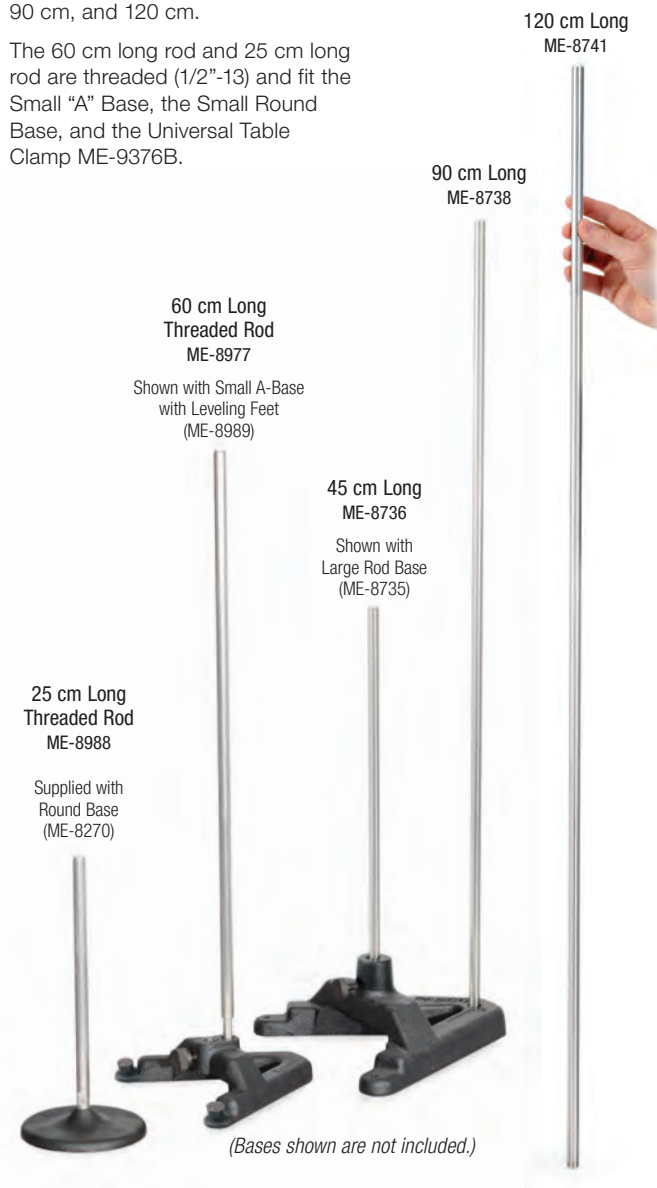
Small A-Base with Leveling FeetME-8989

Stainless Steel Rods

These 12.7 mm (1/2 in.) diameter stainless steel rods do not mar like aluminum rods. They are non-magnetic, very rigid, and durable.

Three different lengths are available in the non-threaded version: 45 cm, 90 cm, and 120 cm.

The 60 cm long rod and 25 cm long rod are threaded (1/2"-13) and fit the Small "A" Base, the Small Round Base, and the Universal Table Clamp ME-9376B.



Order Information

Stainless Steel Rods 12.7 mm (1/2 in.) in diameter:

45 cm Stainless Steel RodME-8736
 90 cm Stainless Steel RodME-8738
 120 cm Stainless Steel RodME-8741
 Round Base with RodME-8270
 Stainless Steel Rod, 60 cm ThreadedME-8977

Flex Rod

ME-8978A

- Flexible rod for holding objects in any orientation

The Flex Rod provides the freedom to place equipment where it's needed. Simply connect the object to the end of the 46 cm long flexible tubing and move it to the desired location. The tubing has enough rigidity to hold many common items in any orientation. In addition, two convenient clamps are included.



Flex Rod holds photogate for Acceleration Due to Gravity experiment using a picket fence (shown with Table Clamp, not included).



The Flex Rod with rod clamp attachment fits sensor handles.



The Flex Rod holds a green laser pointer. Shown with Small "A" Base (not included).



Includes:

- Flex Rod attached to rigid section
- 2 Rod Clamp attachments
- 3-Finger Clamp attachment (Base support not included.)

Order Information

Flex RodME-8978A

Suggested Base Supports:

Small A-Base with Leveling FeetME-8989

Aluminum Table ClampME-8995

Base and Support Rod



Large

Large Base and Support Rod with built-in leveling screws and a threaded aluminum rod that is 12.7 mm (1/2 in.) in diameter and 45 cm long.

Round

Round base with rod. The threaded steel rod is 12.7 mm (1/2 in.) in diameter and 25 cm long.

Order Information

Base and Support RodME-9355

Round Base with Rod.....ME-8270

How to choose the best mounting rod

Both of these rods are useful for mounting sensors, particularly photogates. They also work well with Smart Pulleys.

The SA-9242 stainless steel rod is the same length as the ME-9483 plastic rod. However, the steel rod has a smaller diameter that may not work with all clamps that require a standard 12.7 mm (1/2 in) diameter. The ME-9483 is made of a hard plastic that clamp screws do not dent and it has a threaded brass stud. The lighter weight of the plastic rod will not damage pulleys when thrown into a bin.



Mounting Rods (10 pack)

ME-9483

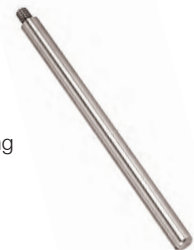
These rigid plastic pulley handles (14 cm long, 1.27 mm diameter) have a 1/4" metal stud that screws into a Super Pulley.



Pulley Mounting Rod

SA-9242

This 14 cm long stainless steel mounting rod is 9.5 mm (3/8 in.) in diameter and fits most standard laboratory clamps, including the PASCO Universal Clamp. It has a standard 1/4"-20 thread.



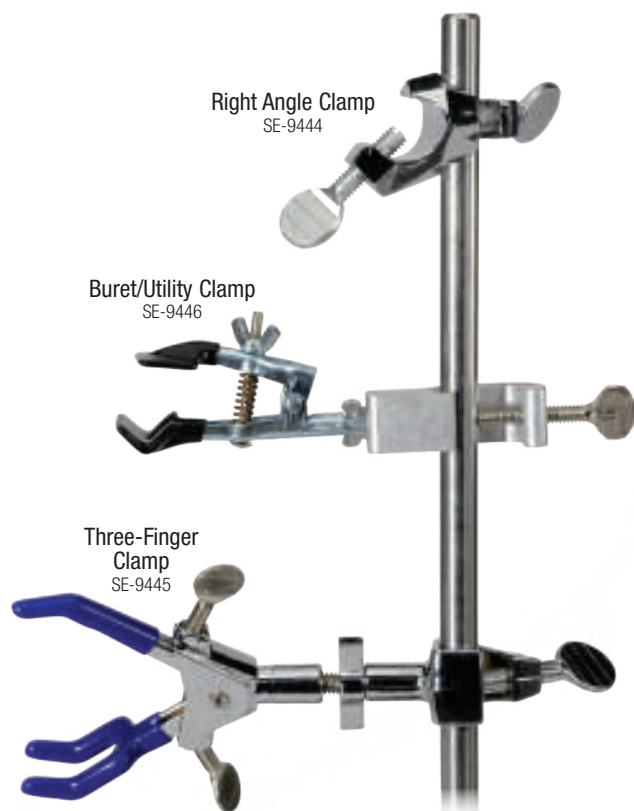
Order Information

Pulley Mounting RodSA-9242

Order Information

Mounting Rods (10 pack)ME-9483

Clamps



Right Angle Clamp

SE-9444

This standard right angle clamp fits rods up to 18 mm (11/16 inch) in diameter.

Buret/Utility Clamp

SE-9446

The V-shaped, plastic-coated jaws of this Buret Clamp open from 5 to 35 mm, rotate 360°, and lock in position at any angle. Fits rods up to 16 mm (5/8 inch) in diameter.

Three-Finger Clamp

SE-9445

Clamp tubes, rods, and irregularly shaped objects. The jaws extend 19 mm, open to 57 mm, rotate 360°, and lock securely at any angle. Fits rods up to 19 mm (3/4 inch) in diameter.

Order Information

Right Angle Clamp	SE-9444
Buret/Utility Clamp	SE-9446
Three-Finger Clamp	SE-9445

Pendulum Clamp

ME-9506



Order Information

Pendulum Clamp	ME-9506	
Shown in use with:		
Photogate Pendulum Set	ME-8752	p. 182
Small A-Base with Leveling Feet	ME-8989	p. 204
45 cm Stainless Steel Rod	ME-8736	p. 204

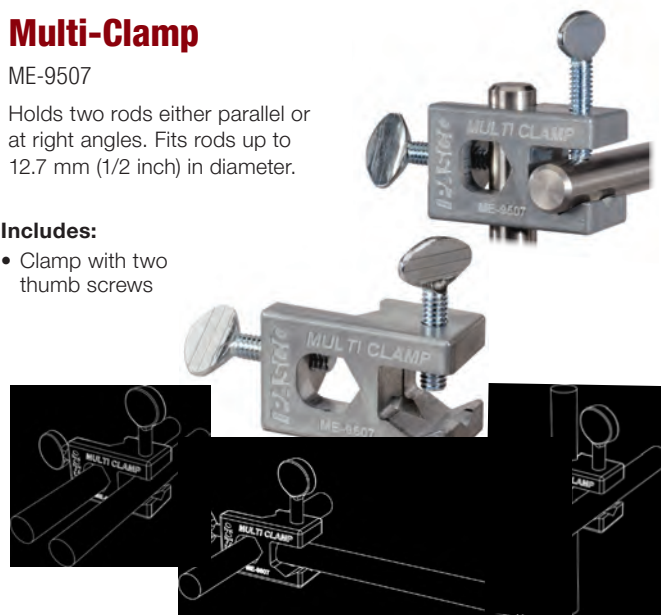
Multi-Clamp

ME-9507

Holds two rods either parallel or at right angles. Fits rods up to 12.7 mm (1/2 inch) in diameter.

Includes:

- Clamp with two thumb screws



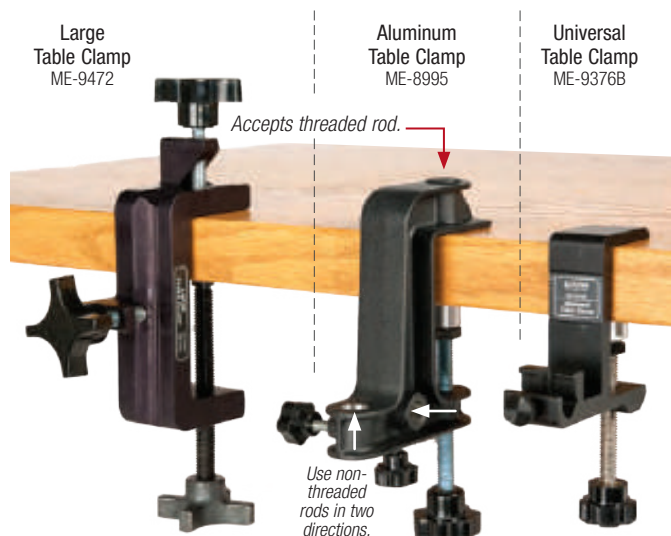
Order Information

Multi-Clamp	ME-9507
-------------------	---------

Large Table Clamp

ME-9472

These clamps hold up to 12.7 mm (1/2 inch) diameter rods that can be mounted either horizontally or vertically.



Order Information

Large Table Clamp	ME-9472
(10 cm grip range)	
Aluminum Table Clamp	ME-8995
(6 1/2 cm grip range)	
Universal Table Clamp	ME-9376B
(6 cm grip range)	

"C" Clamps

SE-7285

This rugged clamp is perfect for attaching a variety of objects to a table. Available in 10 cm (4 inch) size.



Order Information

Large "C" Clamp (6 Pack)	SE-7285
--------------------------------	---------

Laboratory Jacks

Raise, support and align equipment with these Lab Jacks. They're rugged, stable and ensure precise height adjustment. Two sizes are available.

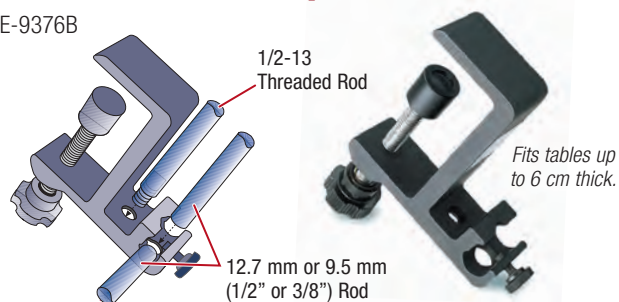


Order Information

Lab Jack	Model	Platform (cm)	Height (cm)	Load (kg)
Medium	SE-9373	15 x 15	7-25	25
Large	SE-9372	20 x 20	7-25	25

Universal Table Clamp

ME-9376B



Attach this Universal Table Clamp to tables or shelves up to 6.0 cm (2 3/8 inch) thick. Can also be mounted on a ring stand.

Mount rods in the clamp either vertically or horizontally. The rods are held securely by stable three-point contacts. Use standard unthreaded lab rods — 9.5 mm (3/8 inch) to 12.7 mm (1/2 inch) — vertically or horizontally. Use 1/2-13 threaded lab rod vertically.

Order Information

Universal Table Clamp	ME-9376B
-----------------------------	----------

Double Rod Clamp (3 pack)

ME-9873

Holds any two rods up to 12.7 mm (1/2 inch) in diameter, either parallel or perpendicular to one another.



Order Information

Double Rod Clamp (3 pack)	ME-9873
---------------------------------	---------

Swivel Clamp (2 pack)

ME-8743

Clamp two rods at any angle or clamp the two rods parallel to each other. Accepts 12.7 mm (1/2 inch) rods.

- Includes Two Clamps



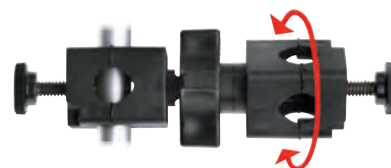
Order Information

Swivel Clamp (2 pack)	ME-8743
-----------------------------	---------

Adjustable Angle Clamp

ME-8744

This unique clamp fits any rod up to 12.7 mm (1/2 inch) in diameter and can lock the rod in place at any angle.



Order Information

Adjustable Angle Clamp	ME-8744
------------------------------	---------

Lab Supplies

30 Meter Measuring Tape

SE-8712A

This 30-meter woven fiberglass measuring tape reads metric on one side and imperial on the other.

**Order Information**

30 Meter Measuring TapeSE-8712A

Digital Calipers

SE-8710



This metric/English (15 cm/6 in.) digital caliper measures to 0.01 mm (0.0005 in.). It has auto power-off and includes a sturdy plastic storage case.

Order Information

Digital CalipersSE-8710

Micrometer

SE-7337A

This low-cost micrometer provides measurements from 0 to 25 mm with 0.01 mm resolution.

Plastic storage box included.

Specifications:

Measurement Range:
0 to 25 mm

Resolution: 0.01 mm

Measuring Face: Carbide

**Order Information**

MicrometerSE-7337A

Aluminum Meter Sticks (6 pack)

ME-7032



These aluminum meter sticks are rigid and straight. Because they are hollow, the aluminum meter stick has about the same mass as a wooden meter stick.

**Includes:**

- Aluminum Meter Sticks (6)

Order Information

Aluminum Meter Sticks (6 pack)ME-7032

Four Scale Meter Stick

SE-8695



The Four-Scale Meter Stick is constructed of plastic square channel. One side has millimeter markings, one has centimeter markings, one has decimeter markings, and the last side has only a one-meter mark.

Order Information

Four Scale Meter StickSE-8695

Half-Meter Stick

ME-7044



This so-called "Half-Meter" Stick is actually 60 cm long. The length of this stick makes it particularly useful for rotation and torque experiments in which the stick is rotated on a Pivot (ME-7034) or Rotary Motion Sensor using the meter stick clamp that is included in the Meter Stick Torque Mass Hanger Set (ME-7035).

Specifications:

Length: 60 cm

Mass: 90 g

Material: Aluminum

Order Information

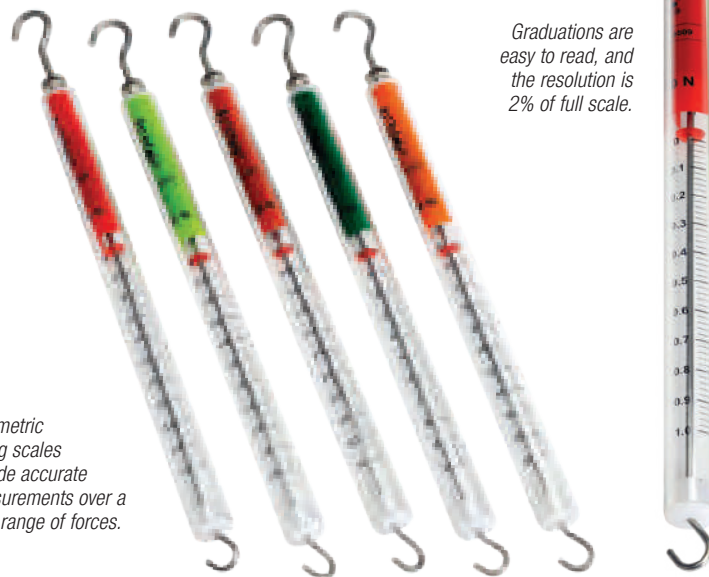
Half-Meter StickME-7044

Metric Spring Scales

These high-quality metric spring scales are precise, durable, and calibrated in Newtons. Five different scales are available. Students can measure forces from a fraction of a Newton to 20 Newtons with excellent accuracy.

Features:

- **Accurate:** The precision springs provide excellent linearity, and the 10 cm long scales are sharp and clear for superior resolution.
- **Sealed Spring:** Can't get tangled, over-stretched, or lost.
- **Zero Adjust:** Turn the knob to zero the balance.
- **Scales on Inside:** They won't wear off.
- **Five Color-coded Ranges:** Measure almost any force from 0.1 N to 20 N.



Graduations are easy to read, and the resolution is 2% of full scale.

Five metric spring scales provide accurate measurements over a wide range of forces.

Order Information

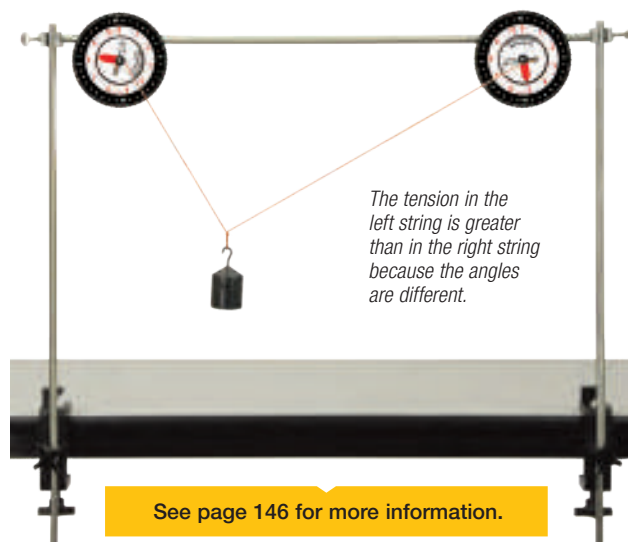
Metric Spring Scales

Model	Range	Resolution	Color
ME-9509	1.0 N	0.02 N	Red
ME-9510	2.0 N	0.04 N	Lt. Green
ME-9511	5.0 N	0.1 N	Brown
ME-9512	10 N	0.2 N	Dk. Green
ME-9513	20 N	0.4 N	Orange

Tension Protractor

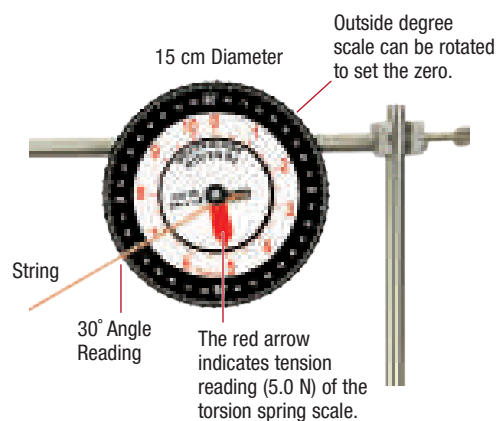
ME-6855

The Tension Protractor is a spring scale and a protractor integrated into one device. Perfect for static equilibrium experiments, the rotary dial indicates the tension in the string and the angle is read where the string passes over the degree scale on the outer ring. Since the Tension Protractor is supported on a rod, it has an advantage over other spring scales that tend to weigh down the string, changing the angle.



The tension in the left string is greater than in the right string because the angles are different.

See page 146 for more information.



- Measure tension and angle with one device
- Large scale for viewing demonstrations
- Zero-adjust for torsion spring scale
- Built-in rod clamp

Order Information

Tension Protractor.....ME-6855

Recommended:

Large Table Clamp	ME-9472	p. 207
90 cm Stainless Steel Rod	ME-8738	p. 204
Multi-Clamp.....	ME-9507	p. 206
Hooked Mass Set.....	SE-8759	p. 215

Lab Supplies

Braided Physics String

SE-8050

► 30-lb. Test

This braided Dacron string is tough, resists stretching, and won't unravel. Withstands up to 133 Newtons of force (equivalent to 13.6 kg). Each roll provides 320 meters of string.



Order Information

Braided Physics String SE-8050

Elastic Wave Cord

SE-9409

In addition to the Slinky, this Elastic Wave Cord is great for wave demonstrations. Unlike a Slinky®, the tension can be varied. The cord is 3 mm in diameter. Each roll provides 90 meters of cord.



Order Information

Elastic Wave Cord SE-9409

Yellow String (2 pack)

ME-9876

Two rolls of highly visible braided yellow cord. Total length of 140 meters.



Order Information

Yellow String (2 pack) ME-9876

Rubber Cord (30 meters)

ME-8986

This rubber cord is used with PASCO's Elastic Bumper. It also fits the Air Track Bumper Set With Holder.



Order Information

Rubber Cord for IDS System (30 meters) ME-8986

Glow String (2 pack)

SE-8690



This stretchy "string" glows in the dark after being exposed to light. Use it to demonstrate wave motion, including resonance and standing wave patterns. Two rolls are included, totaling over 15 meters of string.

WARNING
CHOKING HAZARD
Small parts. Not for
children under
3 years.

Order Information

Glow String (2 pack) SE-8690

Black Thread (3 pack)

ME-9875



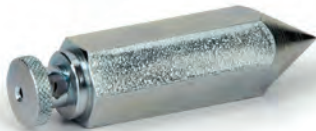
Includes three spools of black Nylon thread

Order Information

Black Thread (3 pack) ME-9875

Plumb Bobs (10 pack)

SE-8728



These finished steel plumb bobs are precision-machined to a fine point. Just slide a string through the hole in the top and tie a knot. The plumb bob hangs precisely centered.

Order Information

Plumb Bobs (10 pack) SE-8728

No-Bounce Pad

SE-7347



Color may vary.

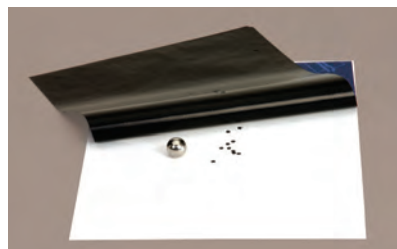
Stop falling objects from bouncing with PASCO's No-Bounce Pad. The 30 cm x 30 cm x 2.5 cm dimensions of the pad provide an ample target for gravity demonstrations. Prevents heavy objects from damaging the floor and prevents falling objects from being damaged on impact.

Order Information

No-Bounce Pad SE-7347

Carbon Paper (100 sheets)

SE-8693



Carbon paper is ideal for marking the position of an object as it strikes the floor or other surface.

Order Information

Carbon Paper (100 sheets) SE-8693

Spirit Levels (10 pack)

SE-8729



These 23 cm long Spirit Levels have three vials with striped gradations to indicate vertical, horizontal, and 45° alignment. The frame is a durable plastic with tough acrylic vials. A magnetic tape allows hands-free leveling.

Order Information

Spirit Levels (10 pack) SE-8729

Freefall Balls Accessory

ME-9890

This set of balls is used with the Discover Freefall system. The special stickers are used to attach the metal washers to the plastic balls, allowing them to be suspended from a magnet.

WARNING
CHOKING HAZARD
Contains small balls. Not
for children under
3 years.



Includes:

- Small Nylon Ball (2.5 cm)
- Large Plastic Ball (10 cm)
- Golf Ball (4.4 cm)
- Hollow Golf Ball (4.2 cm)
- Steel Ball (2.5 cm)
- Steel Ball (1.6 cm)
- Release Washers (10)
- Release Stickers (50)



Order Information

Freefall Balls Accessory ME-9890

Bounce/No Bounce Ball Set (3 pack)

SE-7571

WARNING
CHOKING HAZARD
Contains small balls. Not
for children under
3 years.

These two black balls look and feel identical, but drop them side by side and students will notice a big difference in their elasticity. One bounces close to the original drop height, while the other doesn't bounce at all. Includes three sets of the Bounce/No Bounce Balls. Each ball has a diameter of 2.5 cm.



Order Information

Bounce/No Bounce Ball Set
(3 pack) SE-7571

Small Steel Balls

ME-9872

These 1.6 cm diameter steel balls are used with the Mini Launcher (ME-6825).

WARNING
CHOKING HAZARD
Contains small balls. Not
for children under
3 years.



Order Information

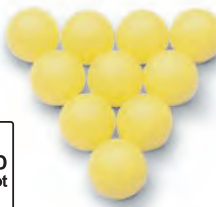
Small Steel Balls (10 pack) ME-9872

Plastic Balls

ME-6822

WARNING
CHOKING HAZARD
Contains small balls. Not
for children under
3 years.

Extra brightly colored balls for the Projectile Launcher. Diameter is 2.5 cm (1 in.).



Order Information

Plastic Balls (10 pack) ME-6822

Steel Balls

ME-9864

Four pack of 2.5 cm diameter balls for use with PASCO Short or Long-Range Projectile Launchers (ME-6800 or ME-6801).



WARNING
CHOKING HAZARD
Contains small balls. Not
for children under
3 years.

Order Information

Steel Balls (4 pack) ME-9864

Spherical Mass Set

ME-8968

This set includes four balls with a diameter of 2.5 cm each, but features various masses, including a hollow steel ball, solid steel ball, plastic ball and aluminum ball.



WARNING
CHOKING HAZARD
Contains small balls. Not
for children under
3 years.

Includes:

- Solid Yellow Nylon Ball (10 grams)
- Solid Steel Ball (66 grams)
- Hollow Steel Ball (21 grams)
- Solid Aluminum Ball (24 grams)

Applications:

- ▶ Race the hollow steel ball and solid aluminum ball down an incline. They have about the same mass, but the solid aluminum ball has a much larger acceleration down the ramp.
- ▶ Fire the yellow plastic, solid steel, and hollow steel balls from a PASCO Projectile Launcher.

Order Information

Spherical Mass Set ME-8968

Balances

OHAUS Electronic Balances

SE-8823A (220 g) SE-8756B (420 g)
SE-8757B (2200 g) SE-8758B (8200 g)



The Ohaus Scout SKX digital electronic balances combine range, resolution, and low cost, making them ideal for the student physics lab.

Simple two-button operation and visual menu prompts allow students to begin weighing with minimal instruction. The large, crisp display is easily viewed from any angle, so teachers can quickly check student results. A sealed front panel, molded spill ring, and removable stainless steel platform provide protection from spills and make these balances easy to keep clean.

Specifications:

SE-8823A:

Capacity: 0-220 g
Resolution: 0.01 g
Pan Size: 12 cm dia.

SE-8757B:

Capacity: 0-2200 g
Resolution: 0.1 g
Pan Size: 16.5 x 4.2 cm

SE-8758B:

Capacity: 0-8200 g
Resolution: 1.0 g
Pan Size: 16.5 x 14.2 cm

SE-8756B:

Capacity: 0-420 g
Resolution: 0.01 g
Pan Size: 12 cm dia.

Order Information

OHAUS Scout SKX Balances	
220g.....	SE-8823A
420g.....	SE-8756B
2200g.....	SE-8757B
8200g.....	SE-8758B

Ohaus USB Adapter

SE-8821

Connect any SKX balance directly to a computer (Windows/Mac), Chromebook, or tablet equipped with a USB port.

Note: Requires PASCO Capstone version 1.8.0 or later or SPARKvue version 2.6.0 or later.

Order Information

Ohaus USB Adapter.....	SE-8821
------------------------	---------

Ohaus Triple-Beam Balance

SE-8723 (without tare) SE-8707 (with tare)



Ohaus Cent-O-Gram Balance

SE-8725



Ohaus mechanical balances have been the standard weighing instruments in student laboratories for decades. They're accurate, easy to use, durable, and inexpensive.

- ▶ **Precision-Ground Steel Knives:** for exact measurements and a long balance life
- ▶ **Stainless Steel Weighing Pan:** easy to clean, lasts indefinitely
- ▶ **Magnetic Damping:** for quick, true measurements
- ▶ **Simple Zero-Adjustment:** just zero the masses, then rotate the knob
- ▶ **Capacities:** see table below

Specifications:

SE-8723:

Ohaus #: 750-S0
Type: Triple-Beam
Capacity: 610 g

With Additional Mass Set: 2610 g
Readability: 0.1 g
Tare: None

SE-8725:

Ohaus #: 311-00
Type: Cent-o-Gram
Capacity: 311 g

Readability: 0.01 g
Tare: None

SE-8707:

Ohaus #: 760-00
Type: Triple-Beam
Capacity: 610 g

With Additional Mass Set: 2610 g
Readability: 0.1 g
Tare: 225 g

Order Information

Ohaus Triple-Beam Balance (without Tare).....	SE-8723
Ohaus Triple-Beam Balance (with Tare).....	SE-8707
Ohaus Cent-O-Gram Balance.....	SE-8725
Recommended:	
Ohaus Additional Mass Set.....	SE-8708

Ohaus Additional Mass Set

SE-8708



For Triple-Beam Balances

These additional masses can increase the range of the Ohaus Triple-Beam Balances (SE-8723 and SE-8707) by an additional 2 kg. Included are a 0.5 kg and two 1 kg masses.

Order Information

Ohaus Additional Mass Set	SE-8708
---------------------------------	---------

Slotted Masses

SE-8726A Set (10 g resolution)

SE-8704A Set (1 g resolution)

SE-8703A Hanger (50 g)



This 50 gram mass hanger is the standard hanger for the slotted masses shown.

These slotted masses provide medium to heavy mass (up to 1.110 kg) with 1 g or 10 g resolution.

The SE-8726A Set Includes:

Masses: 1 x 500 g	2 x 200 g	1 x 100 g
1 x 50 g	2 x 20 g	1 x 10 g

The SE-8704A Set Includes:

The above masses plus a 5 g, 1 g, and two 2 g masses. Mass hangers available separately.

Order Information

10 g Slotted Mass Set.....	SE-8726A
1 g Slotted Mass Set.....	SE-8704A
Slotted Mass Hanger.....	SE-8703A

Gratnells® Rolling Carts

EP-3574 (2-column) EP-3575 (3-column)

Gratnells Rolling Carts are the best way to store and transport PASCO sensors and equipment. They can be configured for trays of any size and include large castors with brakes for added stability.

Designed for Gratnells trays, these movable storage rack carts can store up to 8 (2 column) or 12 (3 column) Gratnells F2 trays (sold separately). Each cart comes with either 16 or 24 pairs of runners.

They can be used to store the equipment kits from the Essential Physics or Essential Chemistry curriculum, the storage trays we offer for wireless sensors, or any of the four sizes of empty trays that we offer for everything else you'd like to store.

Assembly is required.

Trays not included.



EP-3575

Stores up to 12 Gratnells F2 trays
24 pairs of runners
107 cm high, 102 cm wide, 43.5 cm deep



EP-3574

Stores up to 8 Gratnells F2 trays
16 pairs of runners
107 cm high, 70 cm wide, 43.5 cm deep

Order Information

Gratnells Rolling Cart (2-column) EP-3574

Gratnells Rolling Cart (3-column) EP-3575

Gratnells® Storage Trays with Lids



F1

F2

F25

F3

Order Information

Storage Tray (F1) Shallow PS-3326

Storage Tray (F2) Deep PS-3327

Storage Tray (F25) X-Deep PS-3328

Storage Tray (F3) Jumbo PS-3329

These empty Gratnells storage trays with lids have a length of 427 mm and width of 312 mm.

Depths:

F1: 75 mm

F2: 150 mm

F25: 225 mm

F3: 300 mm

Storage Bins (5 pack)

SE-7560



Stackable plastic bins with lids are useful for storing sensors. 14" L x 9.5" W x 6.9" D

Order Information

Storage Bins (5 pack)..... SE-7560

3-Liter Plastic Tub (2 pack)

ME-7559

These containers are great for experiments requiring ice-water baths. Each tub has dimensions of 16.5 cm x 16.5 cm x 20.3 cm.



Order Information

3.8 3-Liter Plastic Tub

(2 Pack) ME-7559

Glassware

This rugged borosilicate glassware is for use in the physics lab. It is particularly useful for buoyancy labs (shown on page 360).



Order Information

Beaker, 100 mL (12 pack) SE-7287

Beaker, 1000 mL (6 pack) SE-7288

50 mL Graduated

Cylinder (12 pack)..... SE-7289

Discover Pi Set

ME-6806

The Discover Pi Set allows students to derive the meaning of π directly from their measurements. This activity transforms π from a constant with unknown origin to a fundamental characteristic of all circular objects.

Includes:

- 4 Disks of different diameters (5.2, 6.4, 8.9, 10.0 cm)
- Transparent Measuring Tape (2)
- Adhesive Stops (2)



Order Information

Discover Pi Set ME-6806

Water Reservoir

ME-8594

This calibrated 1000 mL cylinder is useful for experiments (as shown on page 348), requiring either a specific amount of water, a constant flow of water, or water at a constant pressure. The cylinder has three hose connections: one for connection to a source of water, one for overflow, and an outlet near the bottom. Comes with six meters of tubing and two restriction clips.



Order Information

Water Reservoir ME-8594

Stopwatches

PASCO Stopwatch

ME-1234

- ▶ No alarm or clock
- ▶ Memory for stored event times
- ▶ Uses one AA battery
- ▶ Durable buttons

Are you tired of annoying stopwatch alarms going off all day? Are your students stuck in the clock mode and can't get their stopwatch back into the timing mode? Does your stopwatch stop working after changing that little watch battery? The PASCO Stopwatch solves all these problems.

This stopwatch was designed specifically for science timing. The modes of operation are intuitive and complete instructions are included. The buttons are built to last and it uses a single long-lasting AA battery, which is less expensive than a watch battery (and easier to install).



The PASCO Stopwatch fits comfortably in your hand.



The EVENT/RECALL button allows you to view the last time, in case you forget to write it down. The EVENT/RECALL button is also used to store and recall up to 9 event times: For example, record a series of events, such as times at which sandbags were dropped along the gym floor.



*Two display modes:
MM:SS.SS (00:25.18) or
Decimal Seconds (25.18s)*

Specifications:

LED Display: Visible indoors and outdoors

Two Display Modes: MM:SS.SS (01:25.34) or Decimal Sec (85.34 s)

Precision: 0.01 sec up to 59:59.99 (MM:SS.SS) or 3599.99 s Then 1 sec to 99:59:59 (HH:MM:SS) or 359999 s

Max Number of Event Times: Nine

Auto-off: After one hour idle

Includes: One AA battery and instruction sheet

Order Information

PASCO Stopwatch..... ME-1234

PASCO Stopwatch (10 pack)

ME-1235

- ▶ Includes fitted foam storage box



Order Information

PASCO Stopwatch (10 pack)ME-1235

Mass and Hanger Set

ME-8979

PASCO's Mass and Hanger Set includes varying units of mass that attach to the 5.0 g mass hangers' steel posts. This set includes 4 hangers and 27 masses ranging from 0.5 g to 100 g. The masses are marked on each unit, and each hanger can hold up to 250 g.



Includes:

- Four Mass hangers (5.0 g each) $\pm 2\%$
- Brass masses: $\pm 1\%$
3 x 100 g 3 x 50 g 6 x 20 g
- Aluminum masses: $\pm 1\%$
3 x 10 g 3 x 5 g
- Plastic masses: $\pm 2\%$
3 x 2 g 3 x 1 g 3 x 0.5 g
- Molded storage case

Order Information

Mass and Hanger Set..... ME-8979

Recommended:

Mass and Hanger Spares Kit..... ME-8980
(Contains four mass hangers and 10 each of 2 g, 1 g, and 0.5 g plastic masses)

Replacement Mass Sets for ME-8979:

5-gram Mass Set (set of 6) ME-8981

10-gram Mass Set (set of 6) ME-8982

20-gram Mass Set (set of 6) ME-8983

50-gram Mass Set (set of 6) ME-8984

100-gram Mass Set (set of 6) ME-8985

Large Slotted Mass Set

ME-7566

Includes:

- One 0.5 kg mass hanger (36 cm high)
- Nine 0.5 kg slotted masses (8 cm dia.)



Order Information

Large Slotted Mass Set (5 kg Set)..... ME-7566

Short Slotted Mass Set

ME-7589 (2 kg Set)

Includes:

- One 0.5 kg mass hanger (15 cm high)
- Three 0.5 kg slotted masses (8 cm dia.)



Order Information

Large Slotted Mass Set (2 kg Set)..... ME-7589
Short Mass Hanger ME-7590

Hooked Mass Set

SE-8759



Includes:

- Masses:
1 x 1000 g 1 x 500 g 2 x 200 g
1 x 100 g 1 x 50 g 2 x 20 g
1 x 10 g
- Molded mass holder

Order Information

Hooked Mass Set..... SE-8759

1 kg Mass and Hanger Set

ME-9337 (1 kg set)

Set features a 200 g cast aluminum mass hanger with a steel post, and four "holed" 200 g brass masses that will not fall off the hanger. Multiple mass hangers can be used by hooking the top of one into the bottom of another.



The flat bottom on the mass hanger makes it perfect for use with a Motion Sensor when performing Hooke's Law and spring oscillation experiments.



Can be used in conjunction with the entire set of smaller brass and plastic masses in the ME-8979 Mass and Hanger Set.



Includes:

- Mass Hanger ME-9350, Hanger height: 16 cm
- Set of four masses ME-9351, Diameter of masses: 5 cm
- Steel pin, 8 cm height, 3.6 mm diameter

Order Information

1 kg Mass and Hanger Set..... ME-9337
200 g Mass Hanger ME-9350
200 g Masses (set of 4) ME-9351

Shown in use with:

Bases and Rods..... pp. 204-205

Equal Length Spring Set..... ME-8970

Pendulum Clamp ME-9506

PASPORT Motion Sensor PS-2103A

Thermal Expansion

Thermal Expansion Apparatus

TD-8856

- Use with Multimeter or Temperature Sensor
- Brass, copper, and aluminum tubes included

With PASCO's Thermal Expansion Apparatus, students can accurately and easily investigate the expansion of metals with increasing temperature.

Steam Generator
(sold separately)

Base
Provides storage for
all three tubes



Built-in 10 k Ω Thermistor
Together with a digital ohmmeter, or
Temperature Sensor directly measures the
temperature of the tube

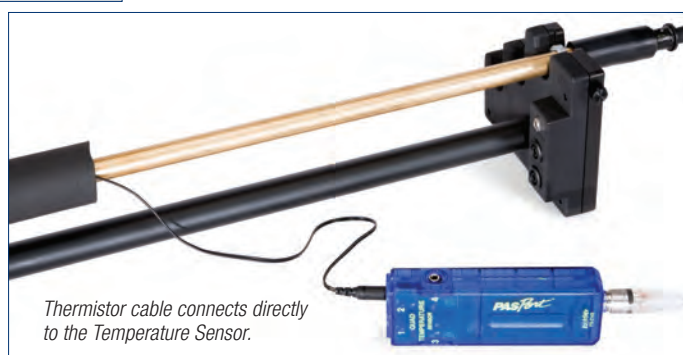
Built-in Digital Gauge
Simple and very accurate
measurements with
0.01 mm resolution

Features:

- **Built-in Digital Gauge:** Measure the rod expansion with 0.01 mm resolution
- **Built-in Thermistor:** A 10 k Ω thermistor is connected directly to each tube and the temperature can be determined using a digital ohmmeter or Temperature Sensor.
- **Heat with Steam or Water:** The fluid used may be steam or water at any temperature.
- **Three Drop-in Metal Tubes:** Each tube connects securely onto the rigid base. The other two can be simultaneously mounted on the base for convenient storage.

Includes:

- Base with built-in dial gauge and thermistor
- Expansion tubes brass, copper and aluminum; 16 mm dia. (80 cm length)



Thermistor cable connects directly
to the Temperature Sensor.

Order Information

Thermal Expansion Apparatus.....	TD-8856	
Required:		
Steam Generator.....	TD-8888	p. 217
Recommended:		
Basic Digital Multimeter.....	SE-9786A	p. 250
OR		
PASPORT Quad Temperature Sensor	PS-2143	p. 40

Steam Generator

TD-8888

- Use with lid on to produce steam.
- Use with lid off as a source of hot water.

The Steam Generator produces steam for thermal expansion and heat conduction experiments. It also can be used with the lid off to heat submerged samples for specific heat experiments.

Specifications:

Maximum Water Capacity: 650 ml

Water Vessel Dimensions: 9.5 cm inner diameter;
9 cm deep

Maximum Temperature with Lid Off:

Approximately 92 degrees C

Maximum Heater Power: 600 W

Rate of Steam Production:

0.24 g/s on setting 9;

0.078 g/s on setting 1.

Outside Material: High
temperature resistant plastic

Hose Fitting: Fits 6 mm
(1/4-inch) ID hose

Heat-resistant Tubing:
1 meter long; 1/4-inch (6.4 mm) ID

Detachable IEC Power Cord:

Power Level Display:
0.56-inch LED (0-9)

Fuse for 110-volt Model:
8A, 250 V Type 5X20

Fuse for 220-volt Model: 4A, 250 V Type 5X20

Mass: 1.2 kg

Approximate Outer Dimensions:
25 cm x 20 cm x 21 cm high

Includes:

- Steam Generator
- Tubing (1 meter long, 1/4-inch (6.4 mm) ID)

See page 218 for additional Steam Generator applications.

Order Information

Steam GeneratorTD-8888



Heater Stirrer

PS-3401

- Removable rod for suspending sensors.



This compact hot plate and stirrer has a white ceramic top that is ideal for heating and for seeing color changes when mixing solutions. It has been designed to withstand spills. Its safety features include warning labels and indicator LEDs. And the included rod makes it easy to support sensors.

When used as a heater:

This compact Heater-Stirrer can boil water in minutes. The ceramic top provides an even heating surface and the indicator LEDs let you know when the top is hot.

When used as a stirrer:

This apparatus is great for mixing solutions. The white top makes color changes during titrations easy to see.

Specifications:

Speed Range: 50-1500 rpm

Plate Diameter: 135 mm

Maximum Temperature: 310°C

Includes:

- Support Rod

Order Information

Heater Stirrer..... PS-3401

Ball and Ring

SE-7597

- Demonstrates thermal expansion

When the Ball and Ring are at room temperature, the ball easily fits through the ring. Heat the ball in a Bunsen burner flame and it expands and no longer fits through the ring. If the ring is also heated, the ball will fit through it once again.

Specifications:

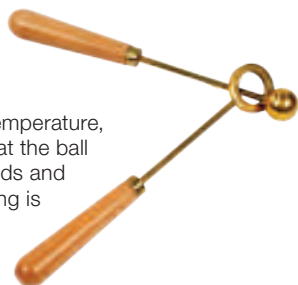
Length: 23 cm

Ball Diameter at Room Temperature: 2.36 cm

Ring Inner Diameter at Room Temperature: 2.39 cm

Order Information

Ball and RingSE-7597



Bimetallic Strip

SE-7598

- Demonstrates differential thermal expansion
- Demonstrates how thermostats work

When heated in a Bunsen burner flame, this bi-metallic strip bends. The strip is steel on one side and brass on the other side. Since brass expands more than steel, the strip becomes longer on the brass side.

As it cools, it becomes straight again.

Specifications:

Blade Length: 12.5 cm

Order Information

Bimetallic StripSE-7598

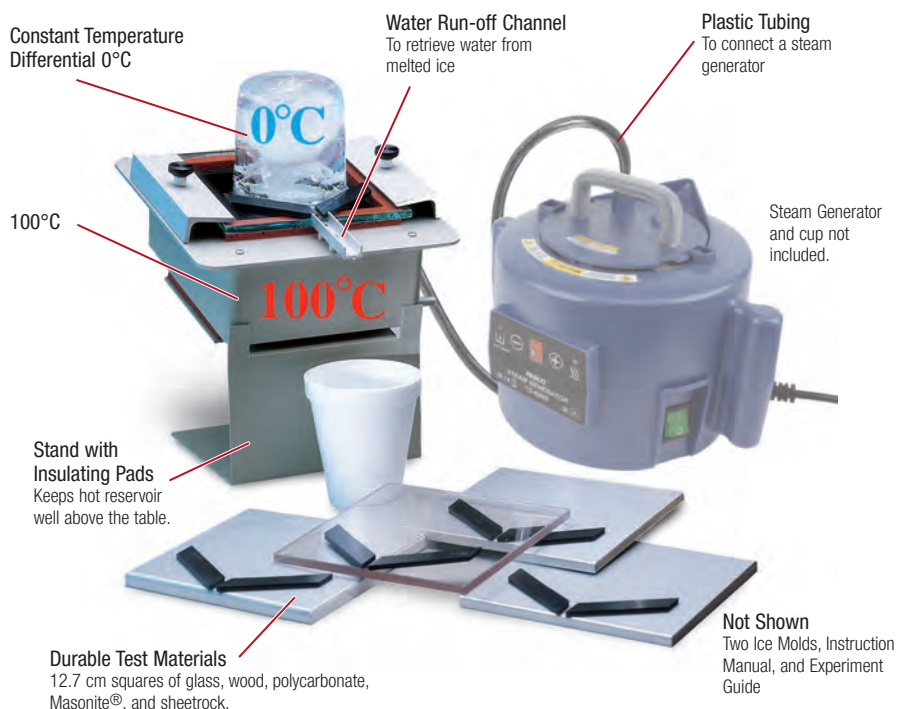


Thermal Conductivity

Thermal Conductivity Apparatus

TD-8561

- Measure heat flow through five different materials
- Constant temperature differential makes calculations easy
- Easy to use, no mess



One of the most important considerations for buildings in the modern world is their ability to provide good thermal insulation. This apparatus gives students a way to observe and quantify heat flow across a constant temperature differential. Students use five common materials as test samples: glass, wood, polycarbonate, Masonite and sheetrock.

Features:

- **No Mess:** The water from the melting ice runs off into the measuring cup — not on the lab table.
- **Durable Test Materials:** The wood, Masonite and sheetrock are covered with a thin aluminum sheet for waterproofing and to ensure good thermal contact.
- **Elevated Steam Reservoir:** The hot reservoir is well above the lab table to eliminate heat damage.

Order Information

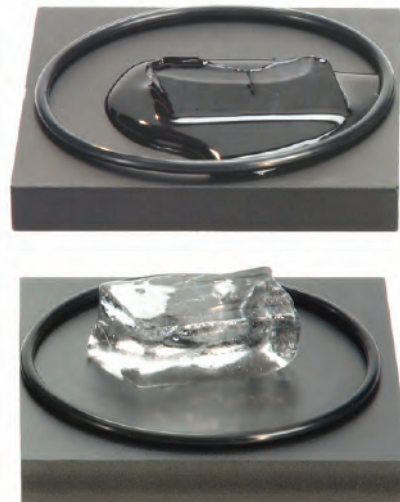
Thermal Conductivity Apparatus..... TD-8561
 Required:
 Steam Generator..... TD-8888
 Graduated Cylinder

p. 217

Ice Melting Blocks

SE-7317

- Great thermal conductivity and heat capacity demonstration



The two Ice Melting Blocks look similar but are composed of different materials. One block feels cold to the touch, while the other block feels slightly warm. Both blocks are at room temperature but have very different thermal conductivities and heat capacities.

After allowing students to hold the blocks, ask them which block would melt ice more quickly. Place an ice cube on each block and watch their amazement as the “cold” block melts the ice cube within two minutes. Melting the ice cube is barely noticeable on the “warm” block. The “cold” block is aluminum and has a much greater ability to transfer heat to the ice cube or the hand.

The “warm” block is plastic, which does not conduct heat as well.

Includes:

- Aluminum Block
- Plastic Block
- O-rings (2)



Order Information

Ice Melting Blocks SE-7317

Basic Calorimetry Set

TD-8557C

► An affordable introduction to thermodynamics

This polystyrene calorimeter cup (7.5 cm inside diameter, 10 cm deep) has 1.3 cm thick walls for excellent thermal properties. Set includes five different metal samples (aluminum, brass, stainless steel, zinc, and copper) and a thermometer.

Applications:

- Define the calorie
- Determine thermal capacity and specific heat of aluminum, copper, brass, stainless steel, and zinc
- Latent heat of fusion

Includes:

- Specific Heat Set SE-6849
- Calorimeter cup with lid
- Partial Immersion Thermometer SE-9084B
- Instruction manual and experiment guide



Order Information

Basic Calorimetry Set	TD-8557C	
Required:		
Steam Generator.....	TD-8888	p. 217
Ohaus Triple-Beam Balance (without Tare)	SE-8723	p. 212
Replacement Supplies:		
Calorimetry Cups (6)	TD-8825A	

Specific Heat Set

SE-6849

This specific heat set has five different materials, all with approximately the same mass (80 g). Each has a hole to tie a loop of string to hang the samples in water.



Includes:

- Aluminum 1.25" d x 1.5" h
- Brass 0.75" d x 1.3" h
- Stainless Steel 0.75" d x 1.5" h
- Zinc 0.87" d x 1.2" h
- Copper 0.625" d x 1.8" h

Order Information

Specific Heat Set	SE-6849
Recommended:	
Calorimetry Cups (6)	TD-8825A

Density Set

ME-8569A

Use this versatile set of materials with the Overflow Can to investigate Archimedes' Principle of displacement, specific heats, and basic length/volume relationships.

Includes pieces that have the same shape, volume, density, and mass, so the variable of interest can readily be isolated. Each piece has a hole, so it can be suspended from a string.



Includes:

- Three cylinders: aluminum, brass, plastic; 2.2 cm dia. x 6.4 cm long (plastic is less dense than water)
- Two blocks: aluminum (1.9 x 3.2 x 4.1 cm) and brass (1.6 x 1.9 x 2.8 cm).
The mass of each block equals that of the aluminum cylinder.
- Irregular shape: aluminum
- Instruction manual

Order Information

Density Set	ME-8569A
-------------------	----------

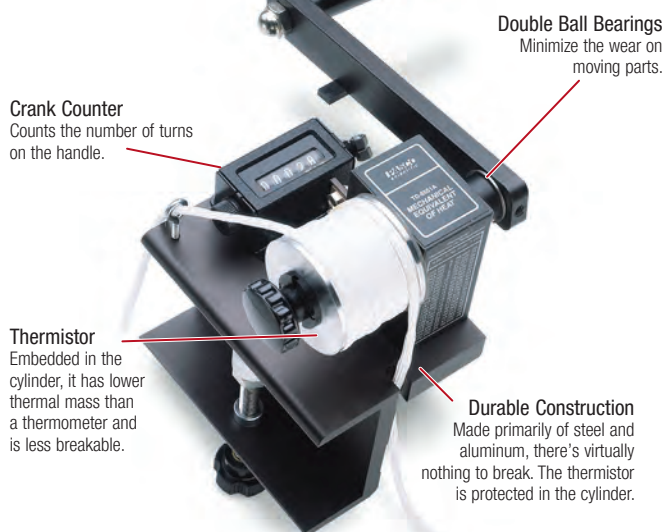
Equivalent of Heat

Mechanical Equivalent of Heat Apparatus

TD-8551A

- ▶ Accurate to 5%
- ▶ Rugged ball-bearing construction
- ▶ Thermistor—no thermometer to break

This Mechanical Equivalent of Heat Apparatus provides an updated version of one of Joule's most important experiments: converting mechanical work to thermal energy.



How It Works:

Turn the crank to perform a measurable amount of work. The crank turns an aluminum cylinder. A flat nylon rope is wrapped several times around the cylinder. As the crank is turned, the friction between the rope and the cylinder is just enough to support a mass hanging from the other end of the rope. This ensures that the torque acting on the cylinder is constant and measurable. A counter keeps track of the number of turns of the crank. The thermal energy is measured by monitoring the temperature of the cylinder using the embedded thermistor.

With this apparatus, the equivalence of work and heat is easily established to within 5%.

Includes:

- Base, cylinder, crank, and counter with a built-in table clamp
- 1-gallon can that can be filled with a measured mass of sand or water (if 10 kg of laboratory masses are not available)
- 3.7 m of flat nylon rope
- Laboratory manual including theory, step-by-step instructions, and data tables

Order Information

Mechanical Equivalent of Heat Apparatus..... TD-8551A

Required:

Basic Digital Multimeter..... SE-9786A p. 250

Ohaus Triple-Beam Balance (with Tare)..... SE-8707 p. 212

A refrigerator (or ice) for cooling the cylinder below room temperature; calipers and a thermometer for measuring room temperature are helpful, but not necessary.

Replacement Supplies:

Replacement Brush..... TD-8583

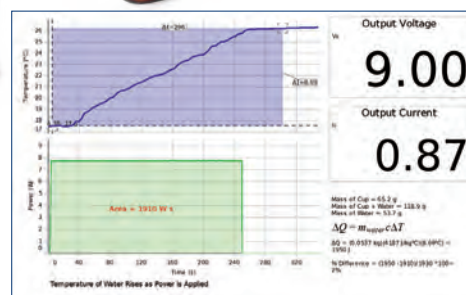
Replacement Cylinder..... TD-8582

Energy Transfer - Calorimeter

ET-8499

- ▶ Compare electrical energy input to changes in internal energy

The Energy Transfer – Calorimeter includes two nested aluminum cups with an air space in between for insulation. While most calorimeters use a coil to heat the water, PASCO's design features a 10 Ω heating resistor mounted to a circuit board. Using temperature, voltage, and current sensors, students can investigate the relationship between the input energy and heat transfer into the water.



The bottom graph displays the power output from the generator, and the top graph shows the increase in temperature. The amount of electrical energy used to heat the water is determined by finding the area under the Power vs. Time curve.

Includes:

- Outer Aluminum Cup (8.9 cm tall, 4.7 cm dia)
- Inner Aluminum Cup (7.5 cm tall, 3.8 cm dia)
- Plastic Lid
- Two-Hole Rubber Stopper
- Heating Resistor with Input Cables



Order Information

Energy Transfer - Calorimeter ET-8499

Recommended for use with ScienceWorkshop:

Temperature Sensor CI-6605A p. 28

Voltage Sensor (unshrouded) UI-5100 p. 29

Current Sensor CI-6556 p. 29

Recommended for use with PASPORT:

PASPORT Temperature Sensor PS-2125 p. 40

PASPORT Voltage/Current Sensor PS-2115 p. 43

Adiabatic Gas Law Apparatus

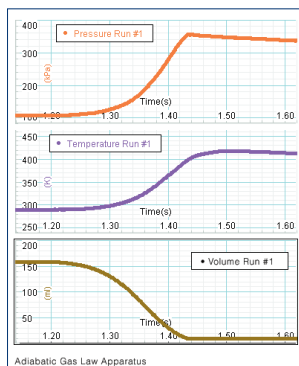
TD-8565

- Investigate the compression of gases
- Computer monitors temperature, pressure, and volume



Three Signal Cables
Carry the volume, pressure, and temperature signals to the computer.

Temperature Sensor
Measures rapid changes in temperature as the resistance of a fine nickel wire changes.



Experiments

PASCO's Adiabatic Gas Law Apparatus can be used with our 850 Universal Interface. The computer functions as a 3-channel storage oscilloscope, generating graphs for pressure, temperature, and volume, as well as integrating the area under a Pressure vs. Volume curve to determine the work done on the gas.

Includes:

- Adiabatic Gas Law Apparatus
- Instruction Manual, Experiment Guide
- Signal Cables 3.5 mm plug to 5-pin DIN
- Power Adapter 9 V DC @ 1 A

Order Information

Adiabatic Gas Law Apparatus TD-8565

Required:
PASCO Capstone Software pp. 8-11
A computer with an interface that will accept three analog signals simultaneously via 5 or 8-pin DIN connectors such as PASCO's 550 and 850 Interfaces.

Compression Igniter

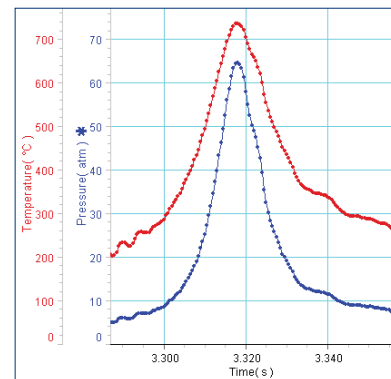
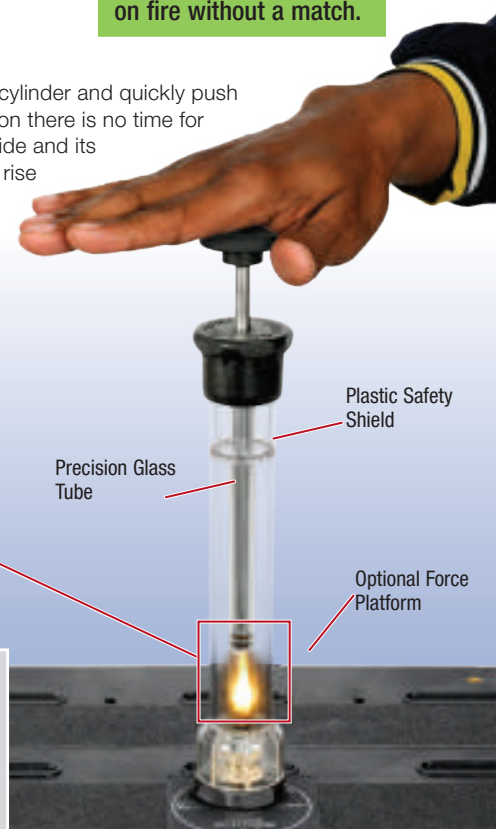
TD-8577

- Adiabatic compression ignites paper!
- Works every time
- Durable and cleanable

Put a small piece of tissue paper into the cylinder and quickly push down on the piston. In a quick compression there is no time for heat to be exchanged between the air inside and its surroundings, causing the temperature to rise well above the combustion temperature of paper.



Students will be amazed to see the paper catch on fire without a match.



Includes:

- Compression Igniter
- Spare Glass Tube with O-rings
- Cleaning Wire
- Complete Instructions with Theory



Order Information

Compression Igniter TD-8577
Replacement Glass Tubes TD-8498A
Shown in use with:
PASPORT Force Platform PS-2141 p. 37

Gas Laws

Ideal Gas Law Apparatus

TD-8596A

- ▶ Experimentally determine the Ideal Gas Law
- ▶ Large syringe for accurate volume measurements
- ▶ Built-in fast response thermistor

Investigating the Ideal Gas Law is simple using PASCO's Ideal Gas Law Apparatus. By connecting a Pressure Sensor and a Temperature Sensor to the syringe, students can quantitatively look at the relationships between pressure, temperature, and volume.

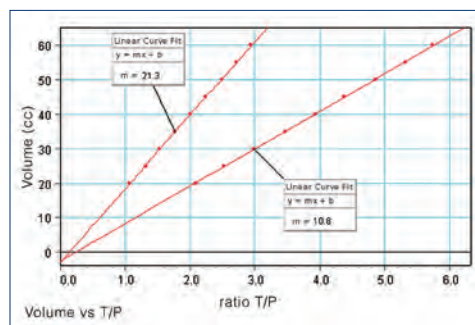
Measure temperature and pressure.

How It Works:

A low thermal mass thermistor is mounted within the syringe for real-time measurement of temperature changes inside the syringe. Tubing and a quick-connect port allow a Pressure Sensor to be directly connected to the syringe. As the plunger of the syringe is depressed, the volume decreases while pressure and temperature increase. The data will help students better understand the Ideal Gas Law.

$$PV = nRT$$

A mechanical stop is included on the syringe plunger to prevent damaging of the thermistor within the syringe and to allow quick (adiabatic) volume changes.



Slope of the Volume vs. $\frac{T}{P}$ graph equals nR .

Includes:

- Ideal Gas Law Syringe
- Built-in Fast Response Thermistor
- Quick-Connect Pressure Port
- Male Luer connectors to attach Wireless Pressure Sensor



Order Information

Ideal Gas Law Apparatus	TD-8596A	
Shown in use with:		
Wireless Absolute Pressure-Temperature Sensor	PS-4257	p. 57
AirLink Interface	PS-3200	p. 18, 50
PASCO Capstone Software	pp. 8-11	

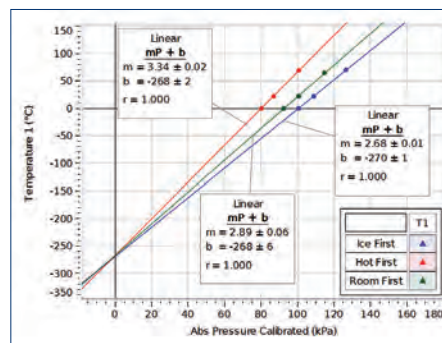
Absolute Zero Sphere

TD-8595

- ▶ Constant volume sphere
- ▶ Measure pressure and temperature directly using PASCO sensors
- ▶ Empirically determine the absolute zero temperature

The Absolute Zero Sphere is an effective tool for determining absolute zero temperature. Students connect Pressure and Temperature Sensors before immersing the sphere in water baths of varying temperatures. As the pressure and temperature change, a live graph is generated in PASCO Capstone™. Once the data is collected, students can use a linear fit to extrapolate the value of absolute zero.

Absolute Zero Apparatus being used with PASPORT Absolute Pressure Sensor



Temperature and pressure data is taken for three temperature water baths. The experiment is repeated with a different amount of gas initially in the sphere. The slopes of the two graphs reflect the change in the number of moles of gas, and both graphs extrapolate to about the same value for absolute zero.

Includes:

- Absolute Zero Sphere
- Built-in Fast Response
- Thermistor Probe
- Quick Connect Pressure Port
- Male Luer connector to attach wireless pressure sensor



Order Information

Absolute Zero Sphere	TD-8595	
Shown in use with:		
Wireless Absolute Pressure-Temperature Sensor	PS-4257	p. 57
AirLink Interface	PS-3200	p. 18, 50
PASCO Capstone Software	pp. 8-11	

Heat Engine and Gas Law Apparatus

TD-8572A

- Measure the actual efficiency of a real heat engine.
- Bring P-V diagrams to life.
- Low-friction graphite piston in glass cylinder
- See the complete experiment (EX-5530B) on page 358.

The Heat Engine and Gas Law Apparatus enables students to perform quantitative Ideal Gas Law experiments, while exploring a functional heat engine. A Rotary Motion Sensor and Pressure Sensor can be added to graph heat engine cycles, determine actual efficiency, and more!

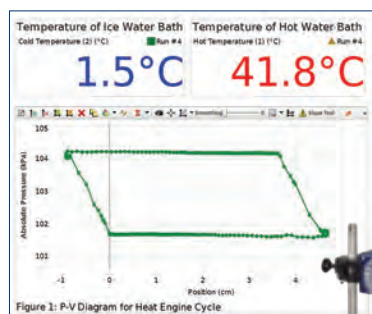
How It Works:

When the air chamber is moved from the cold water bath to the hot bath, the piston rises, lifting the 200 g mass to demonstrate work. The mass is removed, and the air chamber is returned to the cold bath, closing the isobaric/isothermal cycle.

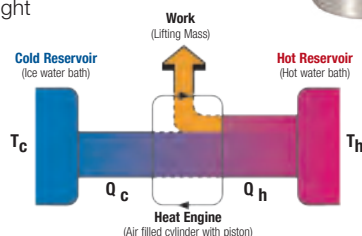
The heat engine cycle is plotted in real time using a Pressure vs. Volume graph.

Pressure in the cylinder is measured by a pressure sensor. Volume is measured by tracking the piston's position with a rotary motion or motion sensor. Temperatures of the hot and cold baths are recorded using temperature sensors.

Students compare the area inside the P-V cycle to the actual work done while lifting the weight to determine how the efficiency of their heat engine compares to the theoretical maximum.



The PASCO Capstone™ graph shows an isobaric/isothermal heat engine cycle operating between a cold water bath at 1.5°C and a hot water bath at 41.8°C.



Includes:

- Heat Engine
- Air Chamber
- Rubber Stopper with hole
- Tubing with Quick-Connect Fittings
- Shut-Off Valve
- 200 g Mass

Specifications:

Piston Diameter: 32.5 mm

Maximum Piston Displacement: ≈10 cm

Order Information

Heat Engine and Gas Law Apparatus.....	TD-8572A	
Shown in use with:		
850 Universal Interface	UI-5000	p. 20
PASPORT Quad Temperature Sensor	PS-2143	p. 40
PASPORT Dual Pressure Sensor	PS-2181	p. 39
PASPORT Rotary Motion Sensor	PS-2120A	p. 35
3-Liter Plastic Tub (2 Pack)	ME-7559	p. 213
Small A-Base with Leveling Feet	ME-8989	p. 204
Stainless Steel Rod, 60 cm Threaded	ME-8977	p. 204

Heat Engine Accessory Included in TD-8572A

TD-8581A

This replacement kit includes a set of parts for the Heat Engine (suitable for both versions TD-8572 and TD-8572A) that are most likely to need replacement after extensive use. These parts connect the air chamber and the Pressure Sensor to the Heat Engine.

Includes:

- Air Chamber
- Rubber Stopper #10 with hole
- Male Luer Lock Barbs (2)
- Female Luer Lock Barbs (2)
- Tube Connector 3/16 x 1/8"
- Plastic Tee for 1/8" Tubing
- One-way Stopcock
- Female In-line 1/8" CPLG (2)
- Polyurethane Tubing 1/8" ID 80 cm

Order Information

Heat Engine Accessory.....	TD-8581A
----------------------------	----------

Heat Engine

Glass Stirling Engine

SE-8636A



This functional Stirling Engine provides a close-up look at the Stirling Cycle Principle with its active pistons and glass cylinders. This highly engaging apparatus connects to a generator which lights LEDs and includes a burner for denatured alcohol, as well as a platform for solid fuel.

**Features:**

- ▶ Completely assembled and ready to run
- ▶ Solid hardwood platform
- ▶ Replaceable Pyrex® power cylinder
- ▶ Replaceable, adjustable Pyrex® heat cap
- ▶ Generator with LEDs
- ▶ Clear cylinders for viewing pistons

Specifications:

Dimensions: 18 cm length x 9 cm width x 8 cm height

Order Information

Glass Stirling Engine SE-8636A

Colliding Spheres

SE-7303

- ▶ Demonstrates transformation of kinetic energy into heat
- ▶ Colliding spheres leave burn mark on paper

Hit these two steel balls together with a piece of paper in between. The kinetic energy is converted to heat and leaves a burn mark on the paper.

**Specifications:**

Diameter: 2 in (5 cm)

Order Information

Colliding Spheres SE-7303

Thermoelectric Converter

TD-8550A

- ▶ Demonstrate the First Law of Thermodynamics
- ▶ Reversible

Features:

- ▶ Demonstrates that a temperature differential is essential for extracting usable energy
- ▶ Produces electrical energy from a temperature differential
- ▶ Produces a temperature differential with electrical energy
- ▶ 15 cm tall with 6 cm diameter fan

**How It Works:**

The Thermoelectric Converter uses a series of semiconductor thermoelectric cells to convert thermal energy into electrical energy. The output from the cells drives a small electric motor.

Heat to Electrical Energy

Place one leg of the Thermoelectric Converter into cold water, the other into hot. The fan turns as the converter draws energy from the hot source (typically a 50°C temperature differential is required).

Electrical Energy to Heat

Pass a current (3 A DC at 5 V) through the Thermoelectric Converter. It acts as a heat pump. One leg becomes warmer while the other becomes cooler.



When a temperature differential is established between the two legs, the fan turns.

Order Information

Thermoelectric Converter TD-8550A

Required:

Containers for holding hot water, cold water, etc.

Triple Output Power Supply SE-8587

Partial Immersion Thermometer SE-9084B

p. 272

PASPORT Non-Contact Temperature Sensor

PS-2197

- ▶ Non-contact
- ▶ -70°C to 380°C



The Non-Contact Temperature Sensor measures surface temperature by detecting the emitted infrared light. Record the temperature of objects without touching them!

Applications:

- ▶ Compare temperature of hands, skin, face, and clothes
- ▶ Measure the temperature of different outdoor ground surfaces
- ▶ Map the temperature profile of an exterior wall

Specifications:

Range: -70°C to 380°C

Accuracy: $\pm 0.5^{\circ}\text{C}$

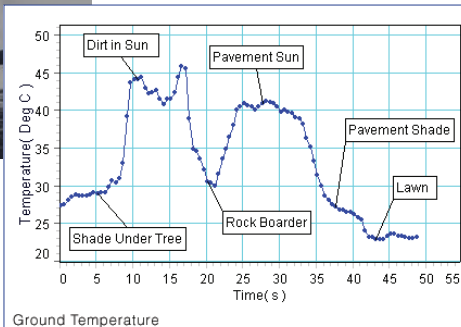
Response Time: Less than 0.1 s

Maximum Sample Rate: 200 Hz

Field of View: $\pm 35^{\circ}$



The student measures the late-morning ground temperature over four distinct surfaces. Starting in the shade under the distant tree, she then crosses bare dirt (in sun), a rock border, pavement, and lawn.



Wireless Thermocouple

PS-4256

NEW



PASCO's Wireless Thermocouple with Display greatly expands the measurement range of our line of temperature-sensing products. This Thermocouple expands our standard thermometers from -40 to 125°C now up to -200 to $+1400^{\circ}\text{C}$. Packaged with a three foot type K thermocouple, its small thermal mass responds quickly to changes in temperature. This is ideal to record the outside surfaces of metal containers with reactions or heat exchange processes. Experiments can be monitored down to temperatures of solutions cooled by commercial freezers (-30°C), dry ice (-78.5°C), or even evaporating liquid nitrogen (-196°C). Students can also use this sensor to measure up to the heat of stove elements, matches, and non-optimized Bunsen burners. Note: An optimal fuel-to-oxygen Bunsen flame can get hot enough to damage the tip of the type K sensor. The tip of the inner blue flame is close to the melting temperature of the solder used in the sensor.

The Wireless Thermocouple can be used to measure the temperature of a flame.



Specifications:

Range: -200 to 1400°C

Accuracy: $\pm 2^{\circ}\text{C}$

Precision: 0.1°C

Maximum Sample Rate: 10 hz

Units Available: $^{\circ}\text{C}$, $^{\circ}\text{F}$, K

Connectivity: USB C, Bluetooth 5.2

Battery Type: Rechargeable LiPO

Logging: Yes

Remote Data Logging Storage: 55,000

Order Information

Wireless Thermocouple with Display PS-4256

Recommended:

Type K Thermocouple PS-2155

Partial Immersion Thermometer

SE-9084B



-20° to 110°C Range

Features 1°C accuracy or better. Filled with environmentally safe non-toxic, non-hazardous, biodegradable Enviro-Safe liquid. Measure from -20° to 110°C with this 30 cm long thermometer. It is clearly marked at 1° degree intervals, and a ring on top allows students to suspend it from a string.

Order Information

Partial Immersion Thermometer SE-9084B

Order Information

PASPORT Non-Contact Temperature Sensor PS-2197

Shown in use with:

PASCO Capstone Software pp. 8-11

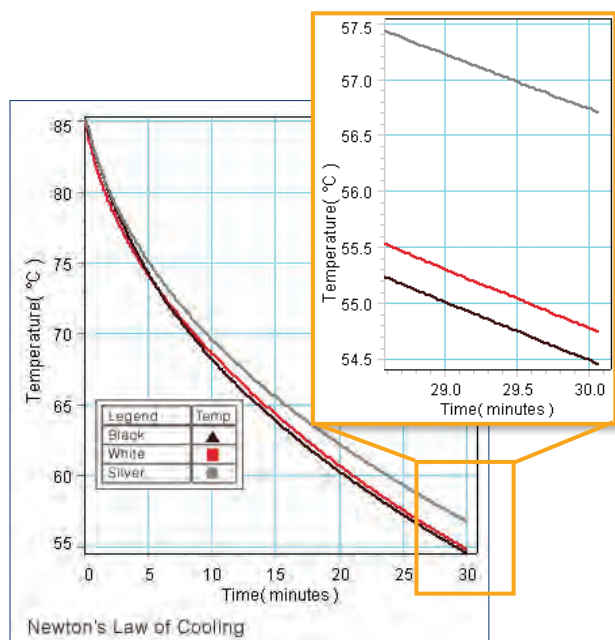
Radiation

Radiation Cans

TD-8570A



These three aluminum cans have different surface finishes: silver (unpainted), white, and flat black. They are 15 cm high and hold about 350 ml of water. Their large thermal mass ensures good results with both temperature probes and standard glass thermometers. Fill them with cool water and place them outside in the sunlight to investigate the effect of the surface finish on solar heating. Or place them inside filled with hot water to discover Newton's Law of Cooling.



The black, white, and silver Radiation Cans are filled with hot water and allowed to cool. Graphs made in PASCO Capstone.

Order Information

Radiation Cans.....	TD-8570A	
Required to measure temperature:		
Wireless Temperature Sensor.....	PS-3201	p. 58
OR		
Partial Immersion Thermometer	SE-9084B	p. 225

Radiation Sensor

TD-8553

- Thermal radiation detector
- Thermopile

Point the Radiation Sensor toward any object – open the shutter and read the digital voltmeter to measure the relative intensity of the thermal radiation emitted.

Flat Spectral Response:

0.6 to 30 μm 

Order Information

Radiation Sensor.....	TD-8553	
Required:		
Basic Digital Multimeter	SE-9786A	p. 250
OR		
Voltage Sensor (shrouded)	UI-5110	p. 29
with 850 or 550 Universal Interface		pp. 20-23

Stefan-Boltzmann Lamp

TD-8555

- High-temperature radiation source

The temperature of this 12 V incandescent lamp filament can be accurately determined by measuring the voltage and current that students supply to the lamp (a graph of Temperature vs. Resistivity is provided).



Order Information

Stefan-Boltzmann Lamp	TD-8555	
Required: 12 V DC Power Supply		

Crooke's Radiometer

SE-7283

- Demonstrates that black surfaces are better radiators

This product consists of a set of vanes, each with one shiny side and one black side, mounted on a spindle in a partially evacuated glass bulb. When exposed to the sun or other intense light, the vanes begin to rotate with the black side trailing. The black side heats the air next to it more than the shiny side, so the air pushes harder on the black side.



Specifications:

Dimensions: Diameter 8 cm; height 13 cm

Order Information

Crooke's Radiometer	SE-7283	
---------------------------	---------	--

Leslie's Cube

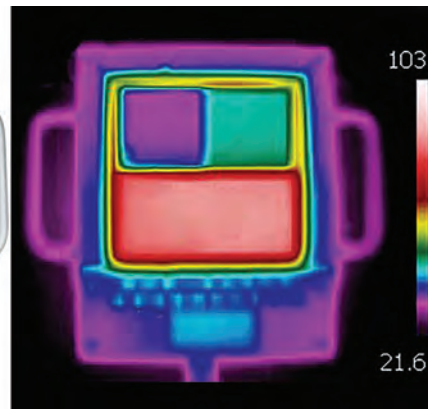
NEW

TD-8350

The classic Leslie's Cube is updated to show all four surfaces together.

The aluminum plate heats to a uniform temperature of approximately 70° C or 100° C, depending on the setting. The four surfaces (black, white, silver, shiny) have different thermal emissivities, causing them to radiate different amounts even though they are all at the same temperature.

Although there are only two set temperatures, it is possible to heat it to any temperature between room temperature and 100° C by turning it off when it reaches the desired temperature. The temperature will stay nearly constant for a while because it takes a long time to cool off.



This shows the Leslie's Cube in visible light on the left and in infrared light on the right.



The Radiation Sensor measures the radiation emitted from each of the four different surfaces. The Radiation Sensor is read with a Voltage Sensor plugged into a 550 Universal Interface.

The Wireless Temperature Link uses the included adapter cable to measure the uniform temperature of the plate.

Surface at 100° C	Radiation Sensor (mV)	% of Black (%)
Black	12.2	100
White	11.9	98
Silver	3.8	31
Polished Silver	1.3	10

Although all the surfaces are the same temperature, each surface radiates a different amount. Notice the white and black surfaces nearly emit the same infrared radiation.

Order Information

Leslie's Cube	TD-8350	
Required:		
Radiation Sensor.....	TD-8553	
Basic Digital Multimeter.....	SE-9786A	p. 250

Complete Thermal Radiation System

TD-8855A



Includes:

- Leslie's Cube
- Stefan-Boltzmann Lamp
- Radiation Sensor

See opposite page for component details.

With the Radiation Sensor, a versatile Leslie's Cube, and the Stefan-Boltzmann Lamp, four key experiments in thermal radiation can be performed:

1. Introduction to Thermal Radiation

Students begin with a study of thermal radiation from different types of surfaces at the same temperature. The Leslie's Cube's four different surfaces are heated to the same temperature and the Radiation Sensor measures the thermal radiation from each surface.

2. Inverse Square Law

The Stefan-Boltzmann Lamp uses a special bulb to provide a near-perfect point source, providing accurate results.

3. Stefan-Boltzmann Law (High Temperature)

Students can verify the Stefan-Boltzmann Law for high temperatures using the Stefan-Boltzmann Lamp.

4. Stefan-Boltzmann Law (Low Temperature)

Students can verify the Stefan-Boltzmann Law for low temperatures using the Leslie's Cube.

Order Information

Complete Thermal Radiation System.....	TD-8855A	
Required:		
Basic Digital Multimeter.....	SE-9786A	p. 250
AC/DC Power Supply.....	SE-9584	p. 271
Recommended:		
2 Meter Patch Cord Set.....	SE-9415A	p. 248

Van de Graaff Generator

Van de Graaff Generator, High Voltage

SE-8691

- ▶ Large sphere creates higher voltage
- ▶ Sparks up to 35 cm in length
- ▶ Large size ideal for demonstrations

The High Voltage Van de Graaff Generator features a 25 cm diameter sphere that can generate approximately 400,000 volts. The size of the sphere, its rounded edges, and its height from the demonstration table contribute to the high voltages generated.

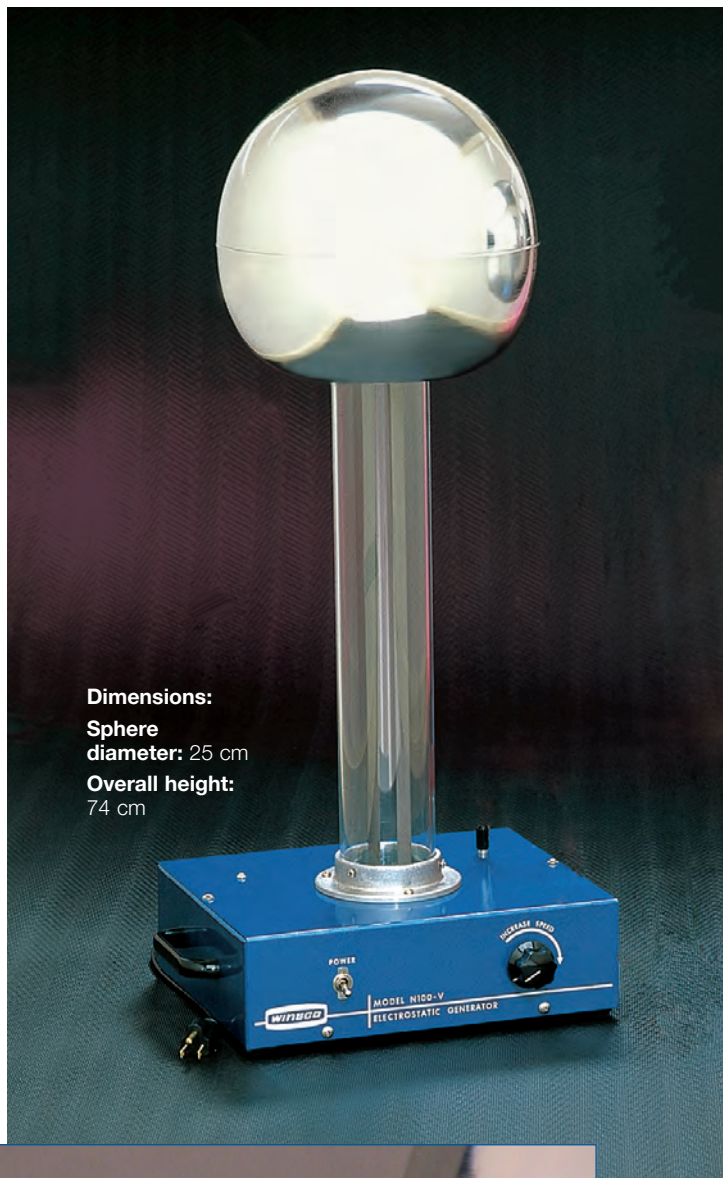
Its large size, long sparks, and high voltages make it ideal for use in larger rooms or lecture halls. An extra belt is included.

Features:

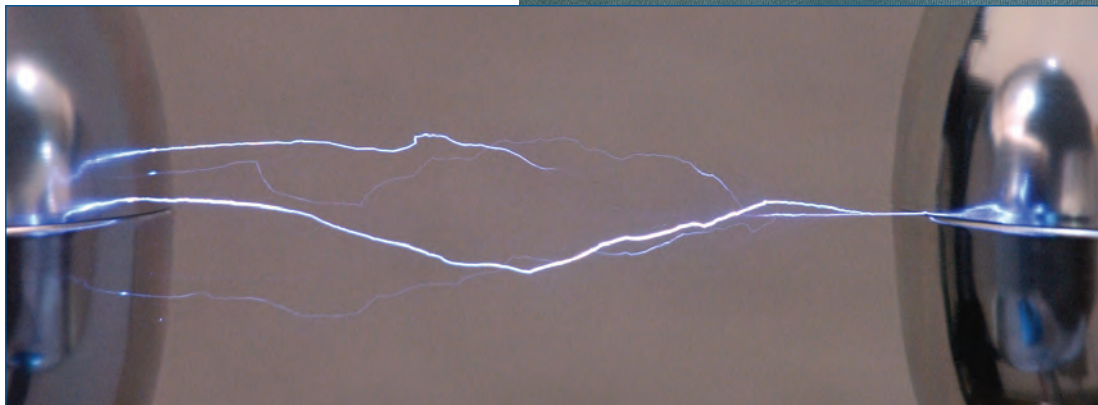
- ▶ Large 25 cm dome for easy visibility
- ▶ Sparks of up to 35 cm in length
- ▶ Tall lucite column keeps sphere far above the base, allowing a large voltage generation, and is thick-walled to withstand years of use
- ▶ Variable speed motor to adjust charge buildup
- ▶ Belt is easy to replace (one extra belt included)

Includes:

- Van de Graaff Generator, High Voltage
- Installed belt
- Replacement belt



Dimensions:
Sphere diameter: 25 cm
Overall height: 74 cm



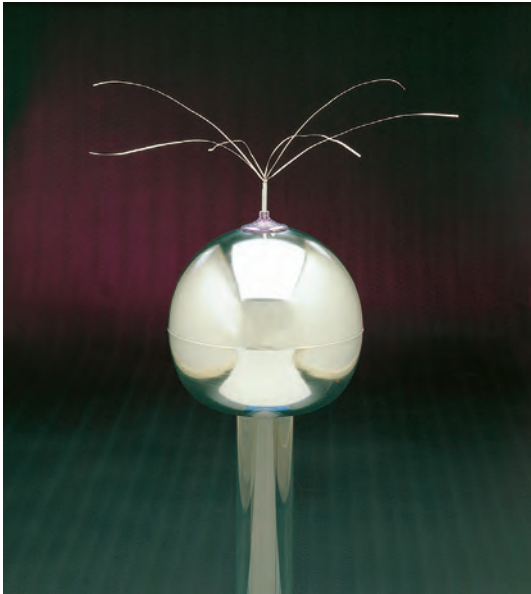
Order Information

Van de Graaff Generator, High Voltage SE-8691
 Replacement Supplies:
 Replacement Belt, Van de Graaff Generator SE-7355

Electrostatic Plume

SE-7232

The lightweight ribbons are connected to a stand that rests on top of the Van de Graaff Generator. As the generator operates, the ribbons stand on end, due to the repulsive force between their like charges.



Order Information

Electrostatic Plume SE-7232

Electrostatic Whirl

SE-7233

When held near the sphere of the generator, the spokes are propelled by charge leaving the points.



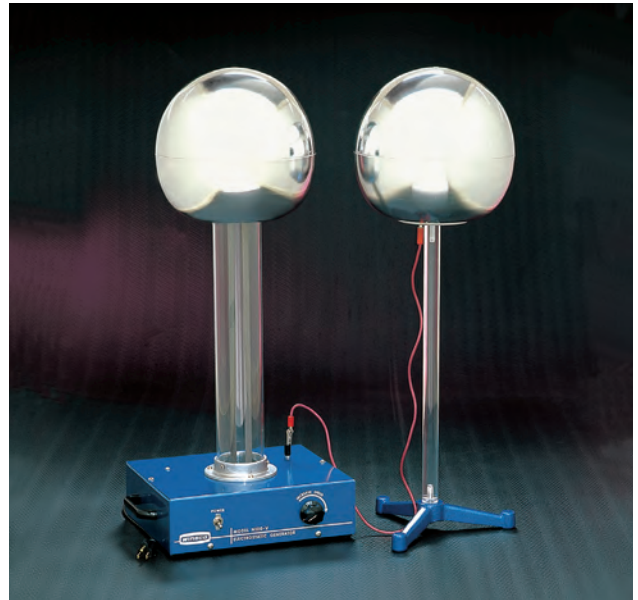
Order Information

Electrostatic Whirl SE-7233

Discharge Sphere

SE-7231

This 25 cm sphere is supported on a Lucite column with a cast iron base. Includes cabling for connection to the Van de Graaff Generator or to a ground.



Order Information

Discharge Sphere SE-7231

Replacement Belt, Van de Graaff Generator

SE-7355

This is the replacement belt for PASCO's Van de Graaff Generator (SE-8691)



Order Information

Replacement Belt, Van de Graaff Generator SE-7355

Electrostatics

Electroscope

SE-7247

Show the amount of charge and the sign of the charge relative to a standard. Includes charging ball plus a set of condenser plates with insulated rod.

Ring diameter: 150 mm



Order Information

Electroscope SE-7247

Coated Pith Balls (set of 10)

SE-7719

These threaded pith balls are coated with a conductive material. Suspend two pith balls from a rod and charge with the Electrostatic Materials SE-6658.

Includes:

- Threaded Coated Pith Balls (10)



Order Information

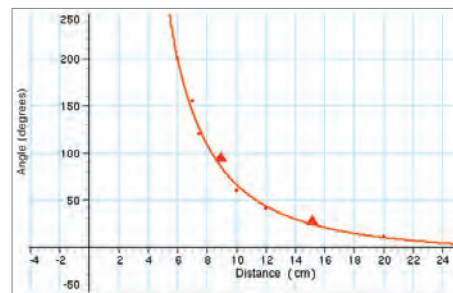
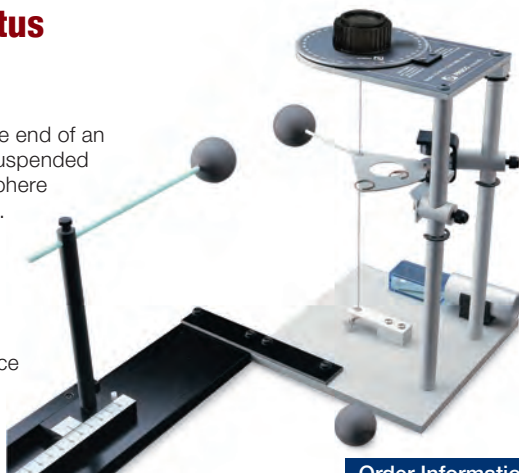
Coated Pith Balls (set of 10) SE-7719

Coulomb's Law Apparatus

ES-9070

How It Works:

A conductive sphere is mounted on the end of an insulating, counterbalanced rod and suspended from a thin torsion wire. An identical sphere is mounted on a calibrated linear track. This second sphere can be positioned at various distances from the first. When the conductive spheres are charged, the force between them is proportional to the twist of the torsion wire that is required to bring the balance back to its equilibrium position. Beginning students can determine the Inverse Square Law in a simple experiment. Advanced students can perform a more sophisticated investigation into all the variables of electrostatic repulsion.



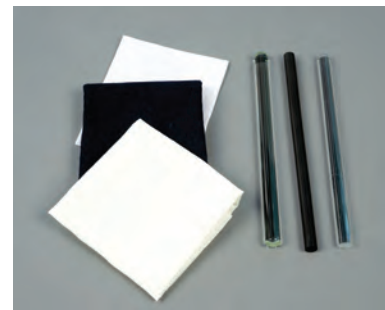
Actual data of the Angle (force) vs. Distance

More information on page 331.

Electrostatics Materials

SE-6658

This electrostatics kit provides the necessary tools to separate positive and negative charges. Students can experiment with different combinations of cloth and rod materials to explore how each becomes charged.



Includes:

- 3 fabric cloths (wool, cotton, silk)
- 3 rods (glass, ebonite, acrylic)

Order Information

Electrostatics Materials SE-6658

Dissectible Leyden Jar

SE-7718

► Acts as a capacitor

This Leyden Jar is designed for classroom demonstrations and comes with a durable inner and outer plate, a plastic dielectric, and instructions. The inner plate has a hook and ball attached, which makes it easy to charge with a Van de Graaff Generator or a charged rod.

Leyden Jar is 3" in diameter and 8" tall.



Order Information

Dissectible Leyden Jar SE-7718

Wireless Electrostatics System

ES-9086

The Wireless Electrostatics System includes all the components needed to perform quantitative electrostatics investigations with the Wireless Charge Sensor.

Perform These Experiments:

- ▶ Charging by friction, contact, and induction
- ▶ Measuring charge on a conductive sphere
- ▶ Explore the electric field around charged objects

Includes:

- | | |
|------------------------------------|----------|
| • Wireless Charge Sensor | PS-3240 |
| • Charge Producers and Proof Plane | ES-9057C |
| • Faraday Ice Pail | ES-9042A |
| • Electrostatics Voltage Source | ES-9077 |
| • Conductive Spheres | ES-9059C |
| • Electrostatics Materials | SE-6658 |



Order Information

Wireless Electrostatics SystemES-9086

Also available separately:

Wireless Charge Sensor

PS-3240



The Wireless Charge Sensor is designed to allow students to measure the electrostatic charge on an object. With the aid of PASCO data collection software, the sensor can measure either charge or voltage and plot them on a variety of displays.

The sensor comes with a BNC-to-alligator clip cable, which can be used to connect the sensor's BNC port to electrostatic equipment such as the Faraday Ice Pail. When used with the Faraday Ice Pail, the Wireless Charge Sensor can measure the total charge on an object by the induction method. The sensor can also be used as a high impedance voltmeter.

The sensor also comes with an E-Field Detector probe that plugs into the BNC port. The E-Field Detector is used to compare the relative charges of objects held near the sensor such as a balloon or a charged strip of cellophane tape.

Applications:

- ▶ Measure charge by induction
- ▶ Quantify the charge on a capacitor plate
- ▶ Discover the charge distribution on a conducting sphere

Features:

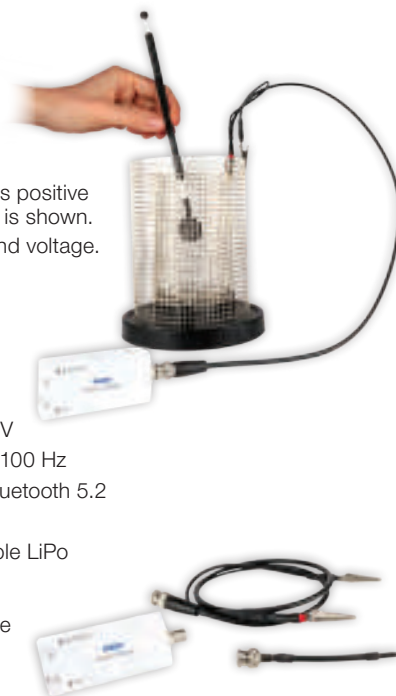
- ▶ No guessing if a charge is positive or negative – the polarity is shown.
- ▶ Measures both charge and voltage.

Specifications:

- Charge:** Range: $\pm 0.1 \mu\text{C}$
Charge: Resolution: 5 pC
Voltage: Range: $\pm 10 \text{ V}$
Voltage: Resolution: 500 μV
Maximum Sample Rate: 100 Hz
Connectivity: USB and Bluetooth 5.2
Logging: Yes
Battery Type: Rechargeable LiPo

Includes:

- BNC-to-alligator clip cable
- E-Field Detector probe
- USB-C cable



Order Information

Wireless Charge SensorPS-3240

Electrostatics Systems

Basic Electrostatics System

ES-9080B

- Quantitative electrostatics
- Comprehensive experiment manual included
- Individual or demonstration use

The PASCO Basic Electrostatics System includes all the components necessary for a quantitative investigation into the basics of electrostatics.

Topics Covered:

- 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
- Moving charges and current



Includes:

- Basic Electrometer: ES-9078A
- Charge Producers and Proof Plane: ES-9057C
- Faraday Ice Pail: ES-9042A
- Conductive Spheres: ES-9059C
- Conductive Shapes: ES-9061
- Basic Variable Capacitor: ES-9079
- Electrostatics Voltage Source: ES-9077
- Experiment Manual

Order Information

Basic Electrostatics
System ES-9080B

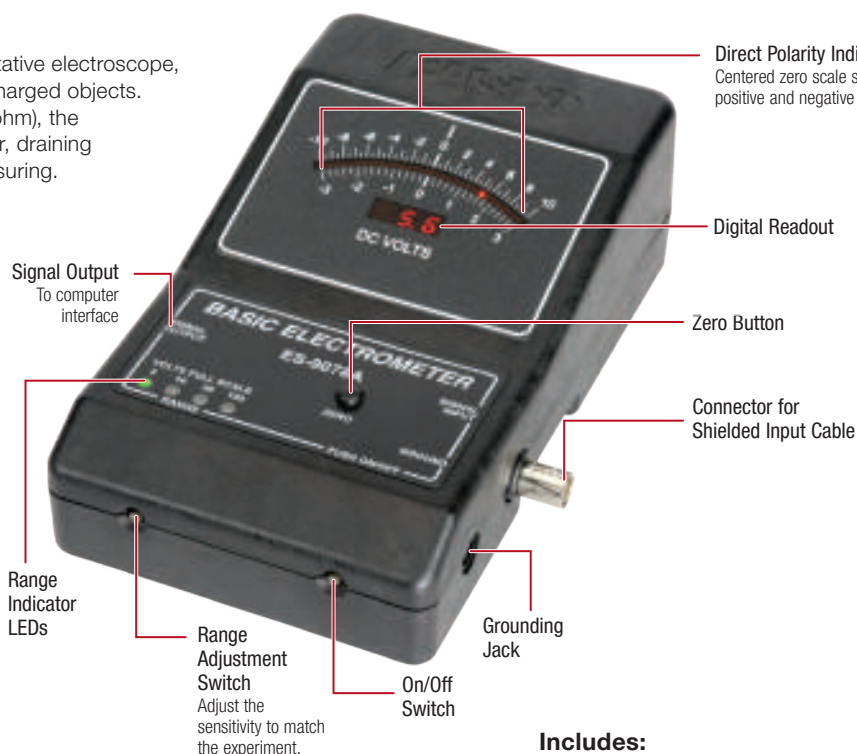
Basic Electrometer

ES-9078A

The PASCO Basic Electrometer is a quantitative electrostatics measuring device, measuring the polarity and magnitude of charged objects. With almost infinite input resistance (1014 ohm), the Electrometer is a high-impedance voltmeter, draining almost no charge from the object it is measuring.

Features:

- **Center-Zero Meter:**
Polarity is indicated directly.
- **Switch-Selectable Ranges:**
3, 10, 30 and 100 VDC.
LED lights indicate the range in use.
- **Zeroing Switch:**
Removes all charge from the input and brings the meter to zero.
- **Automatic Shutoff:**
Turns off about 3 hours after turned on (or used in any way).
- **Output Compatible with PASCO Interfaces:** The interface cable included with the electrometer connects directly to an analog channel on a ScienceWorkshop interface, and connects to a PASPORT interface through an Analog Adapter. This enables the output signal from the electrometer to be recorded, displayed, and analyzed by the data acquisition software.



Includes:

- Shielded input cable to connect the Electrometer to the Faraday Ice Pail or other source of charge
- Grounding cable with clip
- Interface cable
- Instruction and experiment manual

Order Information

Basic Electrometer ES-9078A

Electrostatics Voltage Source

ES-9077



This compact unit is ideal for performing experiments in electrostatics. It may be used as a source of charge or to maintain an object at a constant potential.

Output voltages are 1000, 2000, and 3000 VDC for charging spheres, capacitor plates, etc. A 30 VDC source is also provided for experiments with capacitors.

Specifications:

Output: 30, 1000, 2000, 3000 VDC
±3%, line regulated

Resistance in Series with Output:
120 MΩ/kV

Operating Voltage: 115/220, 50/60 Hz

AC Adapter: 9 VDC

Order Information

Electrostatics
Voltage Source..... ES-9077

Basic Variable Capacitor

ES-9079



Two 18 cm diameter plates allow the capacitance to be varied from 225 pF to zero by sliding the movable plate in its 28 cm long track. The sliding plate has adjustment screws to make the plates parallel to each other. Electrical connection studs are located on each plate.

A BNC connector cable is provided for connection to an Electrometer.

Order Information

Basic Variable
Capacitor..... ES-9079

Conductive Spheres

ES-9059C



These Conductive Spheres (two per set) can be used to store charge or to investigate the charge distribution on one or two spherical conductors. A terminal on the bottom of each sphere provides a connection point for the power supply. Each sphere is attached to a heavy base (for stability) with an insulating rod. The spheres are 13 cm in diameter and 30 cm high.

Order Information

Conductive Spheres..... ES-9059C

Charge Producers and Proof Plane

ES-9057C



The Charge Producers create equal positive and negative charges when rubbed together. The Proof Plane samples the charge density from a charged object. The charge can then be measured using the Electrometer and Faraday Ice Pail.

Use the ball end to sample inside the hollow sphere.

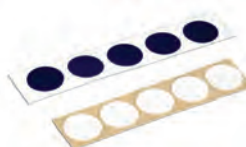
Order Information

Charge Producers and
Proof Plane..... ES-9057C

Replacement Pad Set

ES-9056

(for ES-9057C)



Includes:

- Artificial leather pads (5)
- Blue vinyl pads (5)

Order Information

Replacement Pad Set..... ES-9056

Conductive Shapes

ES-9061



This set includes a conductive sphere with a hole in it. Demonstrate that static charge resides outside the surface of a conductive sphere by sampling the inside surface with the ball end of the proof plane. Also included is an oblong shape for demonstrating the difference in charge densities on a large-radius surface vs. a small-radius surface. The whole surface is at the same potential, and students seem surprised to find that the charge density is greater on the smaller end.

Order Information

Conductive Shapes..... ES-9061

Faraday Ice Pail

ES-9042A



With the Faraday Ice Pail, students can use the Electrometer to measure charge as well as potential.

Touch the Proof Plane to the point of interest on the charged body, then place the Proof Plane inside the Ice Pail. The Electrometer reading will be directly proportional to the charge on the Proof Plane.

The Faraday Ice Pail is 10 cm in diameter and 15 cm deep. It is made of wire mesh, so it is easy to see what is going on inside. The outside shield has a diameter of 15 cm.

Order Information

Faraday Ice Pail..... ES-9042A

Electric Field Mapping

Charge, Equipotential and Field Mapper

ES-9060



The Charge, Equipotential, and Field Mapper is an excellent addition to the Basic Electrostatics System.

Draw any set of two-dimensional conductors with the conductive ink. Investigate the electric field and the equipotential field lines between and around the conductive paper. Charge it and investigate the distribution of charge on its surface.

Similar to the Field Mapper Kit, except it includes electrometer probes, a "point charge" holder, and larger sheets of conductive paper for investigating charge distributions on conductive surfaces.

Includes:

- Conductive paper for mapping charge distributions: 30 x 45 cm (50 sheets)
- Conductive paper with cm grid for mapping equipotentials and field gradients: 23 x 30 cm (100 sheets)
- Pushpins, connecting wire and electrometer probes
- Conductive ink pen and a circular template for drawing conductors
- "Point charge" holder
- Plastic tray with corkboard top: 32 x 48 cm
- Manual with 13 experiments

Order Information

Charge, Equipotential and Field Mapper	ES-9060
Replacement Supplies:	
Special Conductive Ink Pen	PK-9031B
(limited shelf life of six months; not refillable)	
Conductive Paper with Grid	PK-9025B
Conductive Paper (no Grid)	PK-9026

Special Conductive Ink Pen

PK-9031B

The PASCO Conductive Silver Ink Pen makes it easy to study field patterns. Draw over 60 meters of patterns with a single pen. Pen shelf life is six months. Not refillable.

Order Information

Special Conductive Ink Pen	PK-9031B
----------------------------------	----------

Field Mapper Kit

PK-9023



How It Works

Start by investigating standard electrostatic configurations, such as point sources, dipoles, and capacitors. Then go further. You might, for example, investigate whether a person is safe in a car, under a tree, or on top of a flag pole in a thunder storm. Or you might create an electrostatic model of fluid flow to show that water flows fastest in the narrowest portion of a hose.

The procedure is simple:

1. Draw any electrode
2. Plot the equipotentials
3. Plot the electric field

Typical Experiments:

- Dipoles of Like Charges
- Dipoles of Opposite Charges
- Parallel Plate Capacitor
- Point Source and Guard Ring (cylindrical capacitor)
- Floating Electrode

Includes:

- Conductive paper with cm grid: 23 x 30 cm (50 sheets)
- Pushpins (10) and Wires (3)
- Conductive Ink Pen and circular template
- Plastic tray with corkboard top: 32 x 48 cm
- Instruction manual with 10 experiments

Order Information

Field Mapper Kit	PK-9023
Required:	
Basic Digital Multimeter	SE-9786A p. 250
(or any voltmeter with at least a 10 MΩ input impedance)	
Triple Output Power Supply	SE-8587 p. 272
(or another low voltage DC power supply or battery)	
Replacement Supplies:	
Special Conductive Ink Pen	PK-9031B
(limited shelf life of six months; not refillable)	
Conductive Paper with Grid	PK-9025B
Conductive Paper (no Grid)	PK-9026

Resistivity Apparatus

EM-8812

- Slide-wire potentiometer
- Measure resistance and resistivity
- Four wire diameters, five wire materials

A current is established in a wire of known diameter, and the voltage drop across a section of the wire is measured. Students can calculate the resistance of the wire and the resistivity of the material.

$$R = \frac{\rho L}{A}$$

Features:

- **Vary Wire Length:** Slide-wire potentiometer pick-up makes it easy. Use the built-in scale to measure the length of the wire.
- **Vary Wire Diameter:** Four different diameters of brass wire are included. Investigate the difference between resistance and resistivity. Interchange wires quickly and easily.
- **Vary Wire Material:** Five different material wires are included. Investigate how resistivity depends on the wire material.
- **Storage:** Built-in storage tray to hold wires.
- **Sample Wire:** Wires are held securely and straight by the wire guides and lugs.
- **Slide Wire Probe:** Spring-loaded wire probe slides easily along the wire, making contact at a single point.
- **Built-in cm Scale** and slide wire probe make it easy to measure the voltage drop across various wire lengths.

Built-in cm scale and slide wire probe make it easy to measure the voltage drop across various wire lengths.

Sample wire
Wires are held securely and straight by the wire guides and lugs.

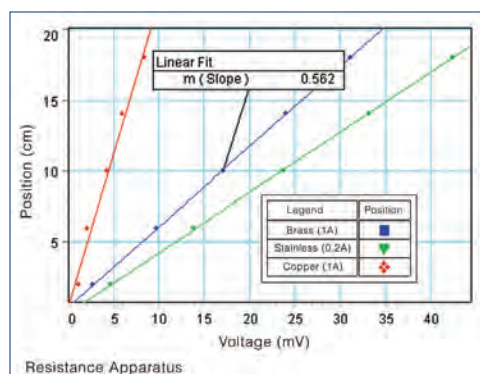
Slide-wire probe
Spring-loaded wire probe slides easily along the wire, making contact at a single point.

Connection to DC power supply

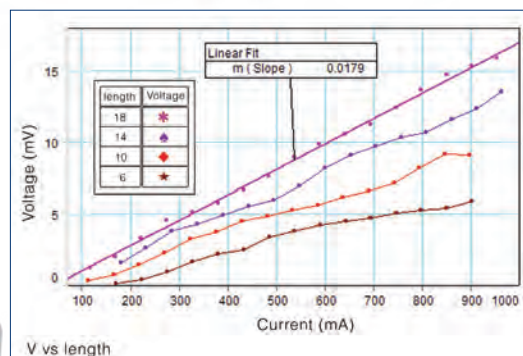
Wire storage tray

Connection to voltmeter

The Resistance Apparatus has a slide-wire probe to easily change the measured length of the wire and utilizes a four wire hook-up to accurately measure the voltage drop. It comes with four different brass wire diameters and four other wire materials.



Graph shows voltage drop across various lengths for three different material wires. The slope of the line (along with wire diameter and current) is used to calculate the resistivity of the material.



For this experiment, the 850 Universal Interface produces a 10 sec voltage ramp to apply a varying current through a brass wire. A graph of Voltage Drop vs. Current is created, and the slope of this line is the resistance of that length of wire.

Includes:

- 30 cm long wires (2 of each):
 - Copper (1.0 mm diameter)
 - Aluminum (1.0 mm diameter)
 - Stainless Steel (1.0 mm diameter)
 - Nichrome (1.0 mm diameter)
 - Brass (0.5 mm, 0.8 mm, 1.0 mm, 1.3 mm diameter)

Order Information

Resistivity Apparatus.....	EM-8812	
Shown in use with:		
850 Universal Interface	UI-5000	p. 20
Voltage Sensor (unshrouded)	UI-5100	p. 29
2 Meter Patch Cord Set.....	SE-9415A	p. 248
Recommended:		
PASPORT Galvanometer	PS-2160	p. 44
Replacement Wires, Resistivity Apparatus	EM-8813	

Circuits

PASCO Modular Circuits

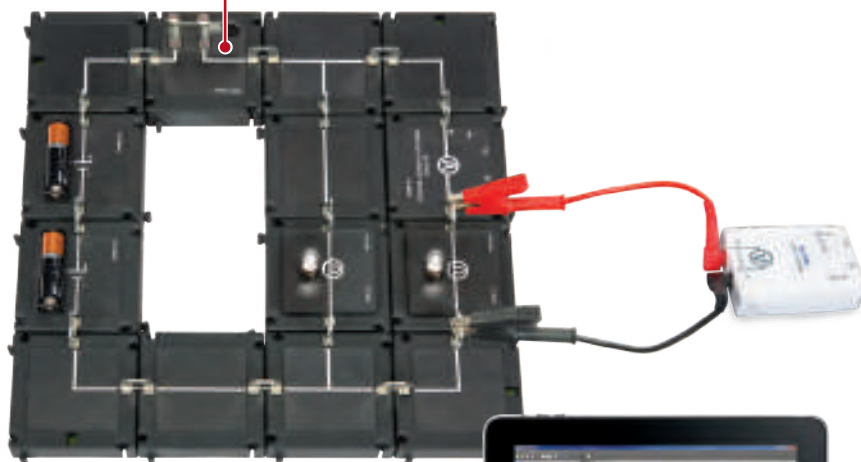
- Puts learning first
- Eliminates confusing wires
- Easy-to-connect modules

These circuit modules are designed specifically for introductory circuits classes. For students who have never wired a circuit, this modular system makes it easy for them to see the layout because it ends up looking like a circuit diagram.

Each module connects mechanically to another by sliding the tabs into each other. It works on any tabletop. No special surface is required. To electrically connect two modules, students insert a jumper clip, which emphasizes that an electrical connection has been made. The large size of the modules (8 cm x 8 cm) enables all the students around the table to see and understand the completed circuit.

Students learn the correct way to insert an ammeter into a circuit: First they remove one of the straight wire modules from their circuit and then they replace it with the Wireless Current Sensor Module. Since the Current Sensor Module is in the same form factor as the other modules, it naturally fits in series with the circuit components. The fact that the Current Sensor is wireless helps the pedagogy: There is only one way in and one way out of the Current Sensor. There are no extra wires coming out of it to confuse students.

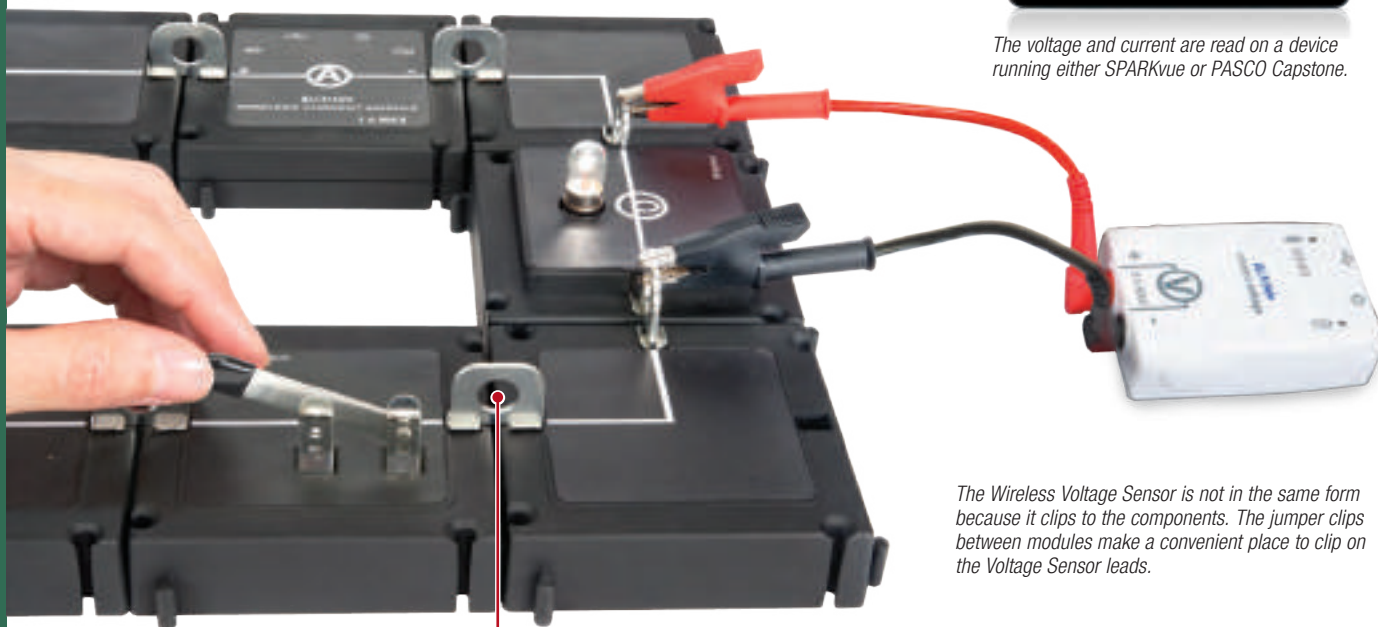
Believe it or not, these two circuits are the same. Which would be easier for your students to understand?



Learn More!



The voltage and current are read on a device running either SPARKvue or PASCO Capstone.



The Wireless Voltage Sensor is not in the same form factor because it clips to the components. The jumper clips between modules make a convenient place to clip on the Voltage Sensor leads.

To electrically connect two modules, students insert a jumper clip, which emphasizes that an electrical connection has been made.



Since the Current Sensor Module is in the same form factor as the other modules, it naturally fits in series with the circuit components.

Wireless Current Sensor Module

EM-3534 (included in EM-3536)

Specifications:

High Current:

Range: ± 1 A

Resolution: 0.2 mA

Low Current:

Range: ± 0.1 A

Resolution: 0.02 mA

Resistance: 0.1Ω

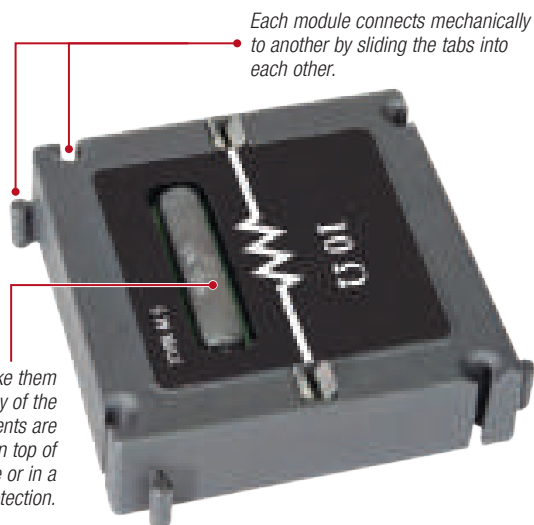
Maximum Sample Rate: 100 kHz

Connectivity: USB and Bluetooth 5.2

Logging: No

Battery Type: Rechargeable LiPo

To make them visible, many of the components are mounted on top of the module or in a well for protection.



Each module connects mechanically to another by sliding the tabs into each other.

See more Modular Circuits Kits and the AC/DC Module on pages 238-239.

Basic Modular Circuits Kit

EM-3535

The Basic Kit has enough modules to do the five basic experiments listed below.

- Ohm's Law
- Series/Parallel Circuits
- Batteries and Bulbs Circuits
- Switches/Open/Closed Circuits
- Electric Power and Energy

Essential Physics Modular Circuits Kit

EM-3536

The Essential Kit has more modules, includes the Wireless Current Sensor Module and Wireless Voltage Sensor, and has 12 experiments.

- Ohm's Law
- Series/Parallel Circuits
- Kirchhoff's Laws
- Batteries and Bulbs Circuits
- Switches/Open/Closed Circuits
- Electric Power and Energy
- Electromagnets
- Electromagnetic Induction
- RC and RL Circuits
- Variable Resistance
- LED Circuits
- Electric Motors

Includes Module	Basic EM-3535	Essential EM-3536
Straight	4	5
Corner	4	4
Resistor	2	3
Light Bulb	2	3
Tee	2	2
Battery Holder (batteries not included)	2	2
SPST	1	1
Capacitor	1	1
Spring Clips	1	1
Inductor	0	1
Motor	0	1
LED	0	1
Potentiometer	0	1
SPDT Switch	0	1
Bar Magnet	0	1
Wireless Voltage Sensor	0	1
Wireless Current Sensor Module	0	1
Extra Jumpers	15	15
Loose Components for Spring Clips	5	5
Gratnells® Case	1	1
Experiments (download)	5	12



Each kit comes in a Gratnells® case with trays that organize the modules.

Order Information

Basic Modular Circuits Kit EM-3535

Essential Physics Modular Circuits Kit EM-3536

Required:

2 AA Batteries

Required for EM-3536:

PASCO Capstone Software see pages 8-11

OR SPARKvue Software see pages 12-13

Also available separately:

Wireless Current Sensor Module EM-3534 p. 60

Wireless Voltage Sensor PS-3211 p. 60

Circuits

Modular Circuits Generator

EM-3455

This versatile hand-crank generator allows students to generate electrical energy and learn what variables affect the output voltage. The generator works by rotating a series of magnets in front of a coil which induces a voltage in the coil. The induced voltage and current are powerful enough to light multiple LEDs and a mini-incandescent bulb.

Applications:

- ▶ Determine which variables affect the induced voltage
- ▶ Design a generator for maximum power output based on the circuit load
- ▶ Investigate mechanical versus electrical energy
- ▶ Create a motor by making the magnets rotate using an AC signal or a Blockly program

Features:

- ▶ Eight removable magnets allow students to vary the number and polarity arrangement
- ▶ Compatible with Modular Circuits coil modules for changing the number of wire turns
- ▶ Gearing helps students to control the speed of the rotating magnets
- ▶ Measure angular speed using the built-in photodetector with a Wireless Smart Gate
- ▶ Works as a motor when connected to the Wireless AC/DC Module

NEW

When used with a Modular Circuits Coil and LED, the generator can light up an LED as the magnets spin near the coil.

Includes:

- Generator Module
- Coated Neodymium Magnets (8 pack): (EM-8849)
- Photogate Cable
- Photodetector Disks (3)
- Pulley Wheel

Order Information

Modular Circuits GeneratorEM-3455

Wireless AC/DC Module

EM-3533

Features:

- Compatible with Modular Circuits
- $\pm 3\text{V}$ Output; 0.3 A Max
- DC, Sine, Triangle, Square
- Bluetooth Low Energy
- Rechargeable Battery
- Controllable with PASCO Capstone or SPARKvue Software

The Wireless AC/DC Module is a Bluetooth Low Energy wireless signal generator designed for use with PASCO's Modular Circuits. The AC/DC Module can act as a DC power supply, as well as generate Sine, Triangle, and Square AC signals. A built-in rechargeable battery provides long-lasting power for your basic circuits, and is rechargeable using the included USB cable. An internal voltage sensor monitors the output voltage at all times. Controllable in either PASCO Capstone or SPARKvue software, this latest circuit module expands the number and type of experiments you can perform with Modular Circuits to include Ohm's Law, RC Circuit Time Constant, and LRC labs.

Programmable using Blockly programming in PASCO Capstone 2 software.

The Wireless AC/DC Module is the perfect power supply for these experiments:

- Series and Parallel Circuits
- Capacitor Charge and Discharge
- RC and LRC Circuits
- Ohm's Law



**Learn
More!**



Wireless AC/DC Module with Modular Circuits

Specifications:

Output Types: DC, Sine, Triangle, Square

Maximum Current: 300 mA

Output Voltage:

Range: $\pm 3\text{ V}$

Resolution: 10 mV

Maximum Sample Rate: 100 kHz

Output Frequency:

Range: 0.01 Hz to 10 kHz

Resolution: 10 mHz

Protection: Overcurrent, Overtemperature, and Back EMF

Maximum Wireless Range: 30 m (unobstructed)

Connectivity: USB or Bluetooth 5.2

Battery Type: Rechargeable LiPo (1000 mA)

Includes:

- Micro USB Cable (PS-3584)

Order Information

Wireless AC/DC Module EM-3533

Requires:

PASCO Capstone Software pp. 8-11

OR

SPARKvue Software pp. 12-13

Circuits

Modular Circuits Advanced Expansion Kit

EM-3556



This expansion pack supplies additional modules for constructing more complex and advanced circuits. The modules in the Modular Circuits Advanced Expansion Kit are intended to be used with (and as an addition to) the circuit modules found in either the Basic or Essential Physics Modular Circuits Kits (EM-3535 and EM-3536). This kit includes a storage case with a custom foam insert.

Includes:

- Speaker Module
- DC Buzzer Module
- Diode Module
- Solar Cell Module
- MOSFET Module
- Bipolar Junction Transistor Module
- Two-Terminal Module
- Jumper Clips (15)
- N-Channel MOSFET Transistor (2)
- P-Channel MOSFET Transistor (2)
- NPN Bipolar Junction Transistor (2)
- PNP Bipolar Junction Transistor (2)
- Gratnells® case with foam, tray, and lid

Order Information

Modular Circuits Advanced Expansion Kit..... EM-3556

AC/DC Expansion Kit

EM-3555



This kit includes the AC/DC Module (EM-3533) and the Modular Circuits Advanced Expansion Kit (EM-3556). This expansion pack supplies additional modules for constructing more complex and advanced circuits. The modules in the Modular Circuits Advanced Expansion Kit are intended to be used with (and as an addition to) the circuit modules found in either the Basic or Essential Physics Modular Circuits Kits (EM-3535 and EM-3536). This kit includes a storage case with a custom foam insert.

The kit includes the wireless AC/DC Module to power the circuits. Also included are:

- Speaker Module
- DC Buzzer Module
- Diode Module
- Solar Cell Module
- MOSFET Transistor Module
- Bipolar Junction Transistor Module
- Two-Terminal Module
- Jumper Clips (15)

Includes:

- Modular Circuits Advanced Expansion Kit (EM-3556) (shown on left)
- Wireless AC/DC Module (EM-3533)

Order Information

AC/DC Expansion Kit..... EM-3555

(The AC/DC Expansion Kit includes everything in the Advanced Expansion Kit, plus the AC/DC Module.)

Now Available – The Extra Modules You Want!

Modular Circuit Individual Components

Purchase individual modules for replacements or additions to your Modular Circuit Kits.

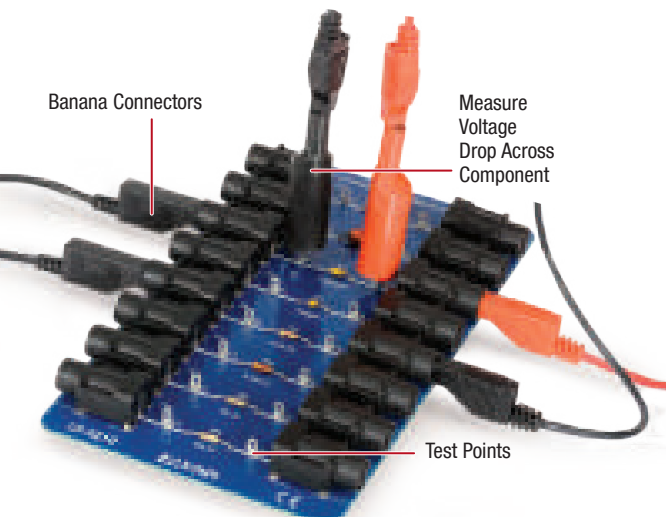
Battery	EM-3430
Two Terminal Jacks	EM-3447
Wire Straight	EM-3445
Wire Corner	EM-3433
Wire Tee	EM-3446
Spring Holder	EM-3444
Switch SPDT	EM-3440
Switch SPST	EM-3441
Light Bulb	EM-3436
Resistor 10 Ω	EM-3439
Resistor 33 Ω	EM-3450
Resistor 100 Ω	EM-3451
Potentiometer	EM-3438
Diode	EM-3434
Red LED	EM-3435
Capacitor 100 μF	EM-3453
Capacitor 330 μF	EM-3454
Capacitor 0.33 F	EM-3432
Coil, 1000 Turn	EM-3448
Coil, 500 Turn	EM-3457
Coil, 2000 Turn	EM-3458
Transistor Bipolar Junction	EM-3449
Transistor MOSFET	EM-3452
Buzzer	EM-3431
Speaker	EM-3443
Motor	EM-3437
Solar Cell	EM-3442

Circuits

Resistor Capacitor Inductor Network

UI-5210

Pair this circuit board with the 850 Universal Interface to study and test RC circuits, circuit laws and theories. The board components can be used to investigate Kirchhoff's Circuit Laws, Ohms' Law, RC Circuits, and A.C. LRC circuit theory with resonant frequencies between 55 kHz and 135 kHz, depending on values used. Designed for use with the 850 Universal Interface.



The circuit board accepts patch cords with shrouded banana terminals.

Shown in use with the 850 Universal Interface power amplifier. Both the applied voltage and the resulting current are measured directly by the 850.

**Includes:**

- Inductor: 6.8 mH, 2.5 mH (2)
- Capacitor: 3900 pF, 560 pF (2)
- Resistor: 47 k Ω , 3.3 k Ω , and two 1.0 k Ω (4)

Order Information

Resistor Capacitor Inductor Network..... UI-5210

RLC Circuit

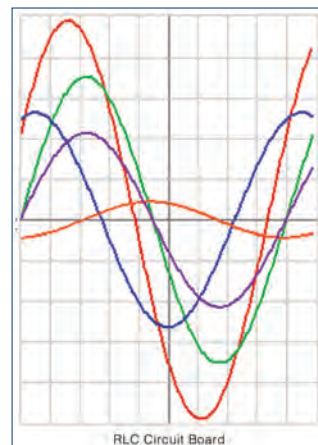
CI-6512

Designed to be used with an 850 or 550 Universal Interface to study the behavior of resistors, inductors, and capacitors in an AC circuit. This board offers a unique set of components for demonstrating:

- ▶ Voltage/Current Phase Relationships
- ▶ RLC Resonance
- ▶ Non-Ohmic Characteristics; components include resistors, capacitors, and an inductor coil.



Phase relationships can be studied between voltage across the capacitor, resistor, and inductor.



The 550 or 850 Interface can measure current and voltage as well as provide power to the RLC Circuit.

**Specifications:**

Resistors: 100 Ω , 1 W; 33 Ω , 5 W; 10 Ω , 10 W

Capacitors: 100 μ F, 16 V; and 330 μ F, 16 V (capacitance values may vary by ± 20 %)

Lamp: 7.5 V, 0.22 A, #50 miniature screw style LED:

Red: 655 nm

Green: 565 nm

Typical Forward Voltage: 1.7 to 2.1 V

Average Brightness at 20 mA: 1.5 mcd

Inductor:

Inductance at 1 kHz: 8.2 mH

Maximum DC Resistance: 6.5 Ω

Current Rating RMS: 0.8 A

3/4" I.D. x 1-3/4" O.D.

Order Information

RLC Circuit CI-6512

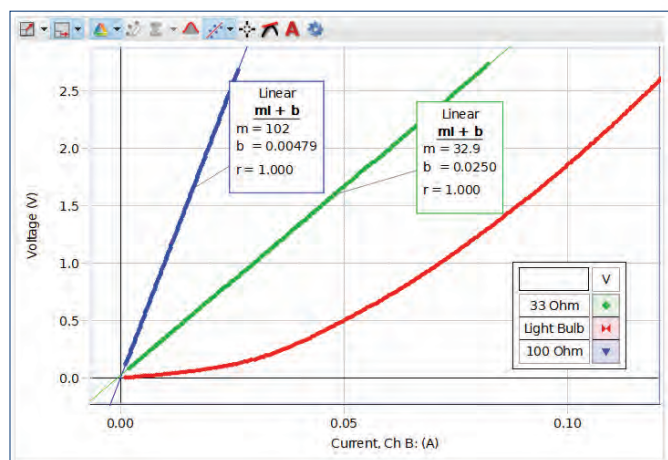
Charge/Discharge Circuit

EM-8678A

The Charge/Discharge Circuit offers a unique way to observe and measure the behavior of DC circuits including batteries, capacitors, light bulbs, and resistors. It also includes an open slot that allows a component to be inserted for further experimentation.

Works Like a Variable DC Power Supply

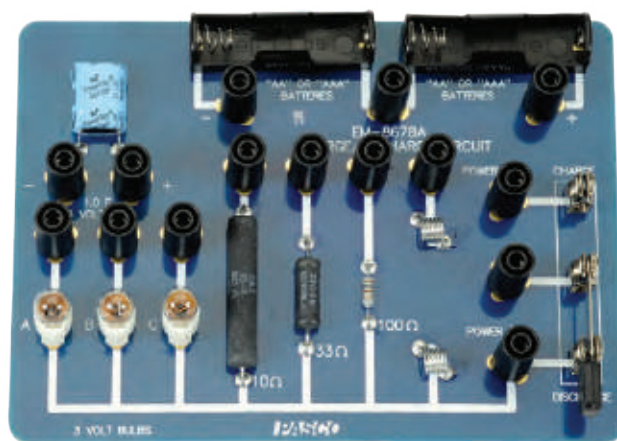
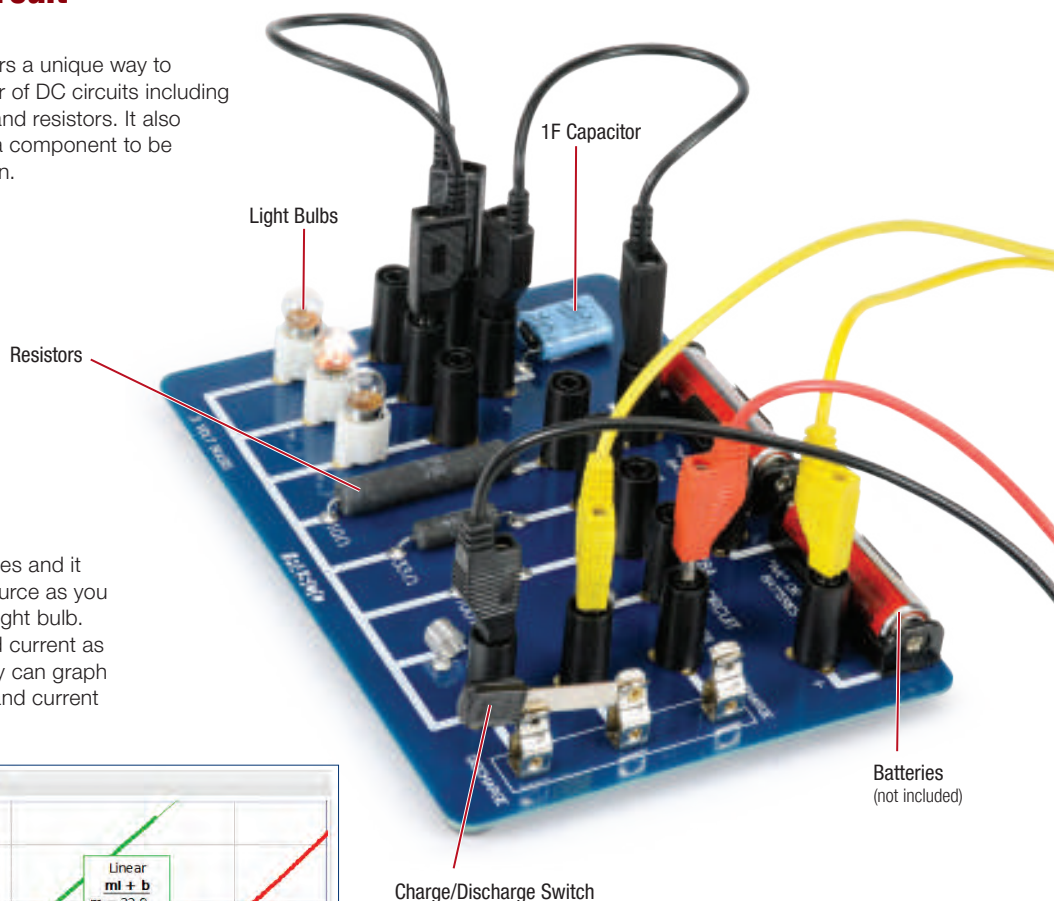
Charge the capacitor using batteries and it will act as a variable DC power source as you discharge it through a resistor or light bulb. Students measure the voltage and current as the capacitor discharges, and they can graph the relationship between voltage and current for various components.



Voltage vs. Current for a 33 Ω resistor, a 10 Ω resistor, and a light bulb. Note the non-linearity for the bulb. Data was recorded in PASCO Capstone using a 550 Universal Interface, Voltage Sensor (UI-5100) and a Wireless Current Sensor (PS-3212).

Includes:

- Farad Capacitor
- #14 Light Bulbs (3)
- 10 Ω Resistor
- 33 Ω Resistor
- 100 Ω Resistor
- Battery Holders (uses AA or AAA; batteries not included)
- Double-Throw Knife Switch
- Instruction Manual



Order Information

Charge/Discharge Circuit	EM-8678A	
Recommended:		
Light Bulbs (#14, 25 pack)	EM-8627	p. 247
4-pack "AA" Batteries (not included)		
Wireless Current Sensor	PS-3212	p. 60
Wireless Voltage Sensor	PS-3211	p. 60
PASCO Capstone Software		pp. 8-11

Circuits

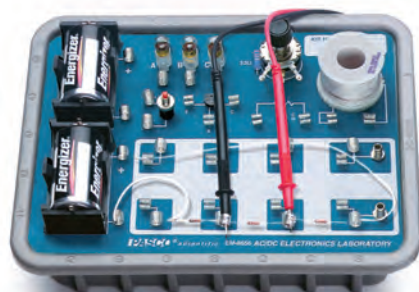
AC/DC Electronics Laboratory

EM-8656

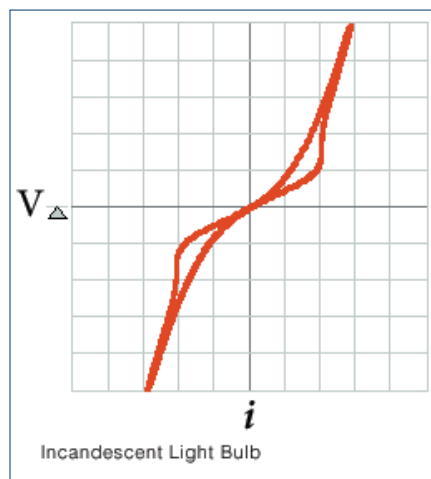
- ▶ Standalone operation
- ▶ Computer compatible
- ▶ Includes coil and iron core

The AC/DC Electronics Laboratory dynamically teaches the basics of AC/DC circuits. It features banana jacks for computer connection, component springs that secure circuit components, a push button switch, light bulbs and sockets, as well as a potentiometer, coil, battery holder, storage tray, and an iron core.

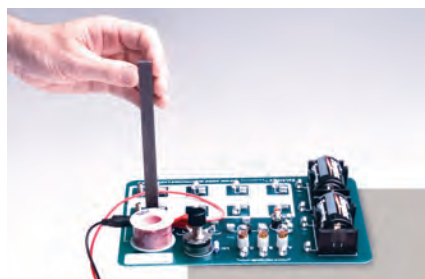
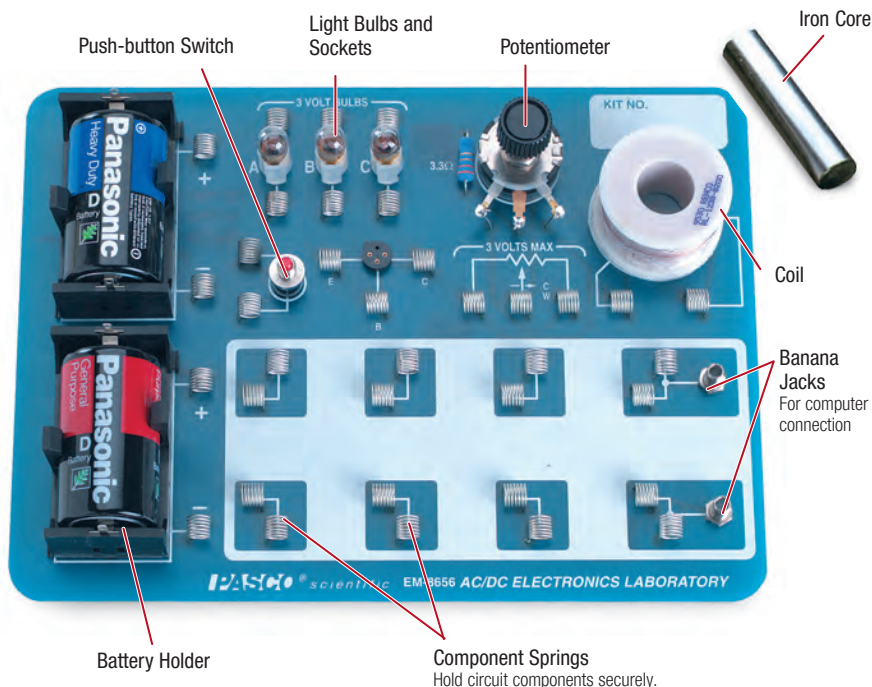
The AC/DC Electronics Laboratory can be used with an 850 or 550 Interface or as a standalone unit with D batteries.



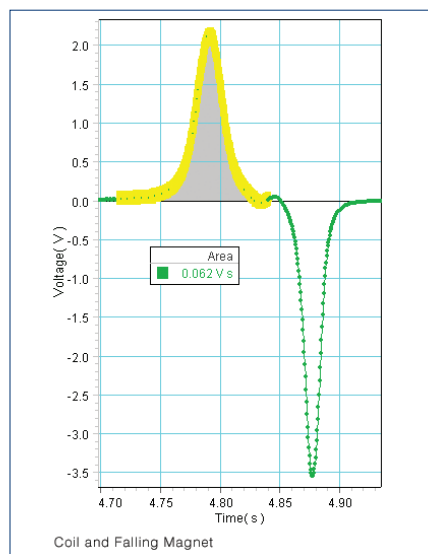
Students study how the resistance of a light bulb filament changes as it heats up. The graph below displays Voltage vs. Current for an incandescent light bulb. It is clear that the resistance is not linear but changes as the bulb begins to glow.



To see the experiments, type the product number into the search box at www.pasco.com and download the manual.

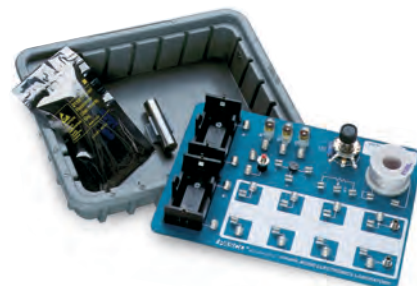


With PASCO Capstone and a Voltage Sensor, students can measure the electromotive force (EMF) created when a magnet is dropped through a coil, as well as the changes in magnetic flux caused by the magnet.



Includes:

- 18 cm x 25 cm circuit board
- Resistors (24)
(4.7 Ω – 220 k Ω , 5%, 0.25 - 5 W)
- Capacitors (7) (1 μ F – 330 μ F)
- Diodes, Transistors, and LEDs
- Wire leads (22 gauge)
- Push-button switch
- Storage tray and laboratory manual
- Battery holders (2)
- Light sockets and lamps (3)
- 25 Ω , 2 W potentiometer
- Component connectors (36)
- Transistor socket
- 8.2 to 19 mH coil and iron core



Order Information

AC/DC Electronics Laboratory	EM-8656
Electronic Components – AC/DC Lab	EM-8668

Basic Electricity Lab

EM-8622

- Durable, easy-to-use kits
- Explore basic electronics
- Complete lab manual

These simple kits provide a strong foundation for future studies in electronics. They take students from the basics of Ohm's Law through simple series and parallel circuit analysis and into some elementary aspects of electronics, where they will build circuits using capacitors, transistors, and diodes. One kit per two students is recommended, giving each student his or her own circuit board.

Includes:

Two Circuit Boards with the following features:

- Battery holders (2)
- Resistor: 3.3 Ω , 2 W
- Light sockets with 3 bulbs (#14)
- Potentiometer: 25 Ω , 2 W
- Spring connectors (32)
- Transistor socket
- Storage tube for holding components (components stay with the kit longer)

Components Package containing:

- Resistors (23) (10 Ω - 220 k Ω , 5%, 1/2 W)
- Capacitors (4) (100 μ F, 330 μ F)
- Diodes (2)
- Transistors (2)
- Wire leads: 22 gauge

Components Set

Circuit Experiment Board

With this board and the included components, students can build a variety of basic circuits, from resistors in series and parallel to a simple amplifier.

Low Voltage

Two D batteries provide all the power needed (batteries not included).

Unique Spring Connectors

Twist them, bend them, push on them: no damage done. These connectors will still hold components and wires securely.



Typical Experiments

- Getting Acquainted
- Series vs. Parallel Circuits
- Ohm's Law
- Resistances in Circuits
- Voltages in Circuits
- Currents in Circuits
- Kirchhoff's Rules (nodes and loops)
- Capacitors in Circuits
- Diodes
- Transistors



To see the experiments, type the product number into the search box at www.pasco.com and download the manual.

Order Information

Basic Electricity Lab
(2 boards)EM-8622
Required:
"D" Cell Batteries
Basic Digital
MultimeterSE-9786A p. 250
Replacement Supplies:
Light Bulbs
(#14, 25 pack)EM-8627
Electronic Components –
Basic Electricity LabEM-8663

Innovative physics textbooks and PASCO physics products

Matter & Interactions is a two-volume textbook and curriculum by Ruth Chabay and Bruce Sherwood, published by Wiley & Sons. It is intended for science and engineering students taking calculus-based introductory university physics. For more information on purchasing these textbooks, visit www.wiley.com.

Electric and Magnetic Interactions

Electric and Magnetic Interactions (Vol. 2 of 2) continues the emphasis on atomic-level descriptions and analysis and modeling physical systems. Electrostatics and circuit phenomena are treated as one integrated subject. The Desktop Electricity Kit allows students to carry out just-in-time desktop experiments on electrostatics, magnetism, and circuits.



Desktop Electricity Kit

EM-8675



When used in tandem with the Electric and Magnetic Interactions textbook, this kit gives students the conceptual tools to further their understanding of electric and magnetic interactions. While its components look simple, they provide hands-on opportunities for students to build powerful conceptual models.

Includes:

- Capacitor 1F, 2.5 V
- Resistor 47 Ω , 0.5 W
- Resistor 100 Ω , 0.5 W
- Lamp Holder T3-1/4 (2)
- #48 Miniature Lamp 2.0 V, 0.6 A (2)
- Incandescent Lamp 2.5 V, 0.3 A (2)
- Battery Holder
- Alkaline Battery D-cell (2)
- Bar Magnet (0.375" x 1")
- Compass, Liquid Filled
- Wire-Red 22AWG (6 ft)
- Alligator Clip Leads (12") (7)
- Nichrome Wire #26 (18")
- Nichrome Wire #30 (18")

Order Information

Desktop
Electricity KitEM-8675

Circuits

CASTLE “2005” Curriculum**Capacitor-aided system for teaching and learning electricity**

- ▶ Complete electricity curriculum
- ▶ Redesigned sections to facilitate beginning CASTLE curriculum in grade 8 or 9

CASTLE Kit

EM-8624A

Economy CASTLE Kit

(for 8 students) EM-8654

The CASTLE™ Approach

CASTLE (Capacitor-Aided System for Teaching and Learning Electricity) is a high school electricity curriculum that leads students from initial naive ideas to an increasingly expert understanding of electrical phenomena. A sequence of self-guided experiments uses large capacitors and transient bulb lighting to help students confront their misconceptions, grasp the physics of current propulsion and build intuitive explanatory models.

**Typical Experiments****Core Curriculum investigates:**

- ▶ What is happening in the wires?
- ▶ What do the bulbs do to moving charge?
- ▶ Where does the moving charge originate?
- ▶ What makes charge move in a circuit?
- ▶ How do wires distribute electric pressure in a circuit?
- ▶ How are values of circuit variables measured?

Advanced Curriculum investigates:

- ▶ Does all matter contain charge?
- ▶ What is the cause of distant action effects?
- ▶ What pushes on tiny charge carriers like electrons?
- ▶ How do semiconductors work?
- ▶ What is AC?
- ▶ How do motors and generators work?
- ▶ How are magnetic and electromagnetic fields produced?



To see the experiments, type the product number into the search box at www.pasco.com and download the manual.

The Curriculum Guide**Download the Manuals FREE.**

Download the CASTLE Curriculum Guide for FREE. At www.pasco.com just type CASTLE in the search box and click GO!

The teacher's manual helps teachers put the CASTLE Kits to the best possible use. The student manual has investigations for each stated experiment, plus commentaries to prepare students for labs, as well as summary exercises to reinforce the lab experience.

Carbon Resistors

These impede flow similar to low resistance bulbs, but don't glow and divert attention to role as energy sinks.

Battery Holder

Securely holds batteries and yet makes them visible so their function within the circuit is evident.

High-Quality Compass

Non-invasive monitoring of movement in wires enables students to visualize the direction of charge flow.

Miniature Light Bulbs

Different shaped bulbs have different resistance values.

Screw Sockets and Stands

Stands provide a sturdy support for bulbs and are easy to quickly connect into a circuit.

25,000 μ F Capacitor

Provides the foundation for this intuitive introduction to current electricity.

Auxiliary Equipment for Core Curriculum

The Mini Generator (1) enables students to distinguish charge circulation from energy transfer. The 100,000 μ F Capacitor (2) lengthens the time scale of transient bulb lighting.

The Kits

Each CASTLE Kit includes all the materials needed (except for three D batteries) for two students to work through a complete introduction to basic electricity. Each Economy CASTLE Kit includes all the materials needed (except batteries) for eight students.

Materials Included in Each Kit

Component	CASTLE Kit	Economy Kit
25,000 μ F capacitor (20 V, nonpolar)	1	4
#14 light bulbs (round)	4	25
#48 light bulbs (oblong)	6	25
10 Ohm resistor	4	16
Miniature light bulb sockets and stands	4	16
Wires with alligator clips	10	40
Battery holder (spring-loaded)	1	4
High-quality compass	1	4
Storage box	1	0

Auxiliary Equipment for Advanced Curriculum

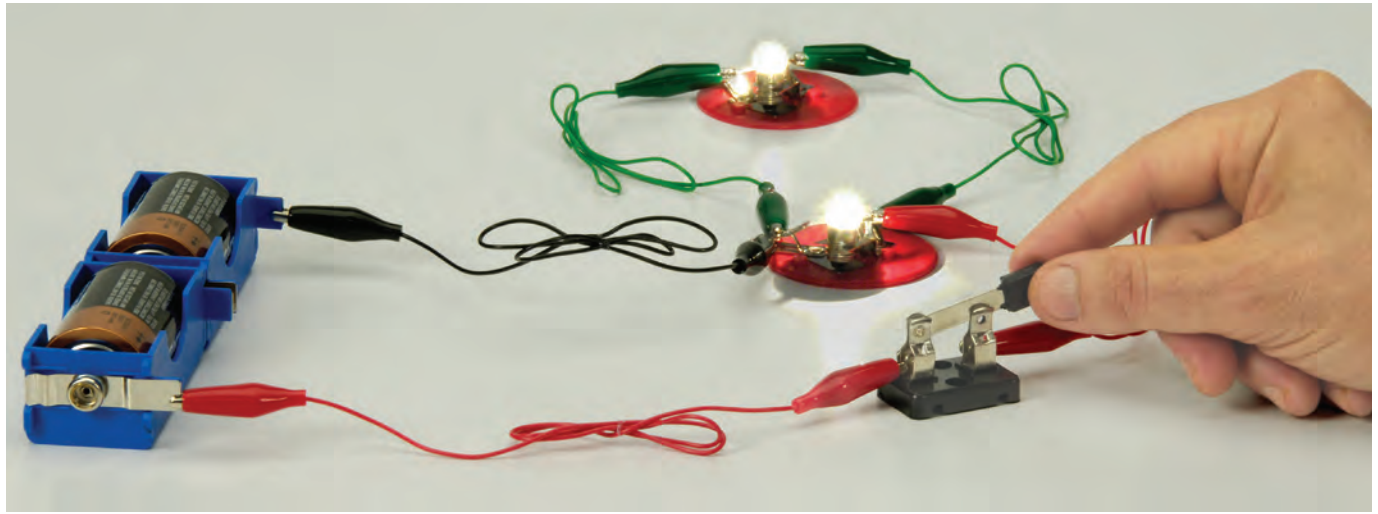
Bi-color LEDs detect electric vectors in electromagnetic fields produced in these coils (3) by accelerating charge when current is turned on and turned off.

Order Information

CASTLE Kit.....	EM-8624A	
Three “D” batteries are required per kit, (not included).		
Economy CASTLE Kit	EM-8654	
12 “D” batteries are required per kit, (not included).		
Recommended:		
Genecon Hand Crank		
Generator	SE-8645	p. 251
Capacitor (0.1 F)	EM-8655	
(Minimum of two each per class)		
Primary/		
Secondary Coils	EM-6709	p. 257
(Minimum of two each per class)		
Replacement Supplies:		
We recommend the purchase of one EM-8627 and one EM-8628 spare bulb set for every five CASTLE Kits, or for every Economy CASTLE Kit.		
Light Bulbs		
(#14, 25 pack)	EM-8627	
Light Bulbs		
(#48, 25 pack)	EM-8628	
Light Bulb Sockets		
(10 pack)	EM-8630	
Liquid-Filled Compasses		
(5 pack)	EM-8631A	
Capacitor		
(0.025 F, 2 pack)	EM-8632	

Circuit Components

Use these standalone components to build your own circuits.



Series/Parallel Battery Holder (10 pack)

SE-8799

This unique battery holder allows "D" cell batteries to be easily connected in both series and parallel. Metal extensions on both sides of the holder are also convenient for use with alligator clips.

Features:

► **Series:** Use the snaps to connect the batteries end to end.



► **Parallel:** Use the metal slides to use the batteries side by side.



Order Information

Series/Parallel Battery Holder (10 pack) SE-8799
Recommended:
Light Bulbs (#14, 25 pack) EM-8627
Light Bulb Sockets (10 pack) EM-8630
Alligator Clip Leads (set of 10) EM-8634

Light Bulb Sockets (10 pack)

EM-8630

Miniature socket has a plastic base with spring-loaded metal clips to hold wire leads. Accepts screw-type miniature bulbs. Includes ten sockets.



Order Information

Light Bulb Sockets (10 pack) EM-8630

Light Bulbs

EM-8627: 2.5 V, 0.3 A bulbs (25 bulbs)

EM-8628: 2.0 V, 0.06 A bulbs (25 bulbs)

EM-8814: 7.5 V, 0.22 A bulbs (25 bulbs)

Screw-type base, suitable for use with EM-8630 Sockets



Order Information

Light Bulbs (#14, 25 pack) EM-8627
Light Bulbs (#48, 25 pack) EM-8628
Light Bulbs (#50, 25 pack) EM-8814

Knife Switches

EM-8815

This single-pole single-throw knife switch has screw terminals and a Bakelite™ base. Through-holes allow for mounting base to another surface.



Order Information

Knife Switches EM-8815

Alligator Clip Leads (set of 10)

EM-8634

Use these 30 cm long Alligator Clip Leads for almost any application — from hooking up instruments to bread boarding circuits. They come in sets of 10: two each of yellow, white, red, green and black.



Order Information

Alligator Clip Leads (set of 10) EM-8634

Replacement Bulbs (5 pack)

EM-8679

The Replacement Bulbs (5 pack) is a replacement part for the:

- Series/Parallel Circuit (EM-8677)
- Introductory Optics System (OS-8500)

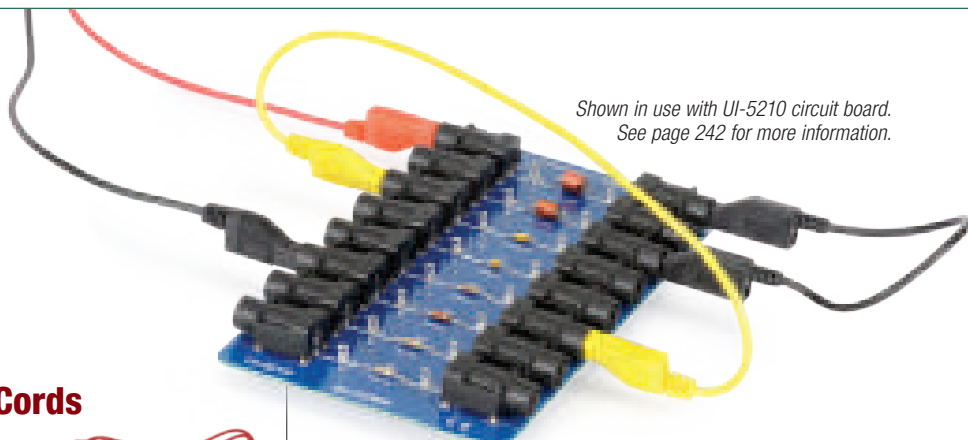


Order Information

Replacement Bulbs (5 pack) Series/Parallel Circuit EM-8679

Patch Cords

These stackable patch cords come in four convenient lengths. The grips are made of soft plastic for flexible strain relief. Spring connectors rotate in the grips, reducing wear due to friction.



*Shown in use with UI-5210 circuit board.
See page 242 for more information.*

2-Meter Shrouded Patch Cords

SE-9711

These shrouded patch cords are two meters long. There is one red and one black patch cord. The banana connectors are shrouded for safety.

Set includes one red and one black shrouded patch cord (each 2 meters long)



Order Information

2-Meter Shrouded Patch Cords SE-9711

2 Meter Patch Cord Set

SE-9415A

These heavy insulation patch cords are convenient and durable. The grips are stackable and made of soft plastic for flexible strain relief. The spring connectors rotate in the grips, reducing the wear due to friction. The wire itself is 18 AWG.

Set includes 2 red and 2 black patch cords.



Order Information

2 Meter Patch Cord Set SE-9415A

Banana Plug Cord Sets, 30 cm Length

SE-7123

These insulated 30 cm patch cords are convenient, durable, and inexpensive.

The stackable grips are made of soft plastic for flexible strain relief and the spring connectors rotate, reducing wear due to friction. This set of 8 includes 2 red, 2 yellow, 2 blue, and 2 black.



Order Information

Banana Plug Cord Sets, 30 cm Length SE-7123

Alligator Clip Leads (set of 10)

EM-8634

Use these 30 cm long Alligator Clip Leads for almost any application — from hooking up instruments to bread boarding circuits. They come in sets of 10: two each of yellow, white, red, green and black.



Order Information

Alligator Clip Leads (set of 10) EM-8634

Banana Plug Cords (5 pack)

SE-9750 (red) SE-9751 (black)

These heavy, insulated patch cords are convenient, durable and inexpensive. The grips are stackable and made of soft plastic for flexible strain relief. The spring connectors rotate in the grips, reducing wear due to friction.

The 75 cm long cords are available in red or black.



Order Information

Banana Plug Cord-Red (5 pack) SE-9750
Banana Plug Cord-Black (5 pack) SE-9751

Shrouded Long Patch Cords

EM-9740 (red) EM-9745 (black)

Set of five 75 cm long shrouded patch cords in red or black. Terminals are shrouded banana plugs.

Maximum rating: 30 Vrms or 60 VDC, 10 Amps.



Order Information

Shrouded Red Patch Cords EM-9740
Shrouded Black Patch Cords EM-9745

High Voltage Patch Cord Set

SE-9269

Shrouded (4 mm) male banana plug to right-angle shrouded male banana plug 120 cm long (one red and one black).



Order Information

High Voltage Patch Cord Set SE-9269

Alligator Clip Adapters

SE-9756

Convert banana plugs into alligator clips with this set of 10 adapters. The 4 mm banana plug clips are tin-plated steel. These adapters just slide over the end of your 4 mm banana plug. Set includes 5 red and 5 black insulated adapters.



Order Information

Alligator Clip Adapters..... SE-9756

Shrouded Alligator Clip Adapters

SE-9758

Designed for use with both regular and shrouded banana plugs, this set of adapters comes with 5 red and 5 black shrouded alligator clip adapters.



Order Information

Shrouded Alligator Clip Adapters SE-9758

Spade to Banana Adapter

EM-8629

For use with both regular and shrouded banana plugs. Includes five red and five black adapters.



Order Information

Spade to Banana Adapter..... EM-8629

Shrouded Alligator Test Leads

PS-3544

These test leads are included with the Wireless Voltage Sensor (PS-3211). They can also be used with the Wireless Current Sensor (PS-3212). Includes one red and one black lead.



Order Information

Shrouded Alligator Test Leads PS-3544

Resistor Pack

EM-8784

Assortment of electrical resistors including 10 each of the following:
10 Ω , 100 Ω , 330 Ω , 560 Ω ,
1000 Ω , 3300 Ω , 10 k Ω , 22 k Ω ,
100 k Ω , 220 k Ω , 330 k Ω .



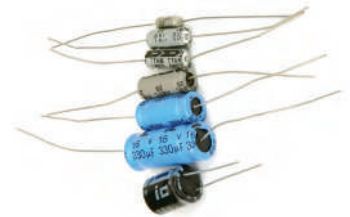
Order Information

Resistor Pack..... EM-8784

Capacitor Pack

EM-8785

Assortment of electrical capacitors ranging from 1 microfarad to 470 microfarads.



Order Information

Capacitor Pack..... EM-8785

Capacitor (0.1 F)

EM-8655

(0.1 F) Electrolytic, bipolar, 10 V capacitor with screw terminals, 4.5 cm diameter, 14 cm long.



Order Information

Capacitor (0.1 F) EM-8655

Capacitor (0.025 F, 2 pack)

EM-8632

Electrolytic, bi-polar, 25 Volt capacitor with screw terminals, 5 cm diameter, 8 cm long. Contains 2 capacitors



Order Information

Capacitor (0.025 F, 2 pack) EM-8632

Capacitor (1 Farad)

SE-8626

Electrolytic, bipolar, 5 V 1.0 F capacitor. Charge up this capacitor with the Mini Generator and then let go of the crank. The handle will continue to rotate in the same direction as the capacitor discharges.



Order Information

Capacitor (1 Farad) SE-8626

Multimeters

Basic Digital Multimeter

SE-9786A



This basic meter includes all of the functions and ranges needed for most introductory lab work.

Features:

- ▶ 10 amp range
- ▶ Backlit display with 25 mm digits
- ▶ Soft rubber boot for drop protection
- ▶ Built-in tilt stand
- ▶ Type K thermometer built in for surface or air measurements
- ▶ Auto power off saves battery life

Specifications:

DC Voltage: 0.1 mV to 600 V with $\pm 0.5\%$ accuracy

AC Voltage: 1 mV to 600 V with $\pm 0.3\%$ accuracy

DC Current: 0.1 μ A to 10 A

AC Current: 0.1 mA to 10 A

Resistance: 0.1 Ω to 20 M Ω

Additional Functions:

Input fuse protection, audible and visible misconnection signals, data hold freezes display reading

Display: 3-1/2 digit display with 25 mm digits, polarity indication, low battery indication

Power: 9 V battery (included)

Order Information

Basic Digital Multimeter SE-9786A

Precision Digital Multimeter, Component Tester and Thermometer

SB-9631B



This is an excellent general purpose multimeter that features high-accuracy overload protection on all ranges and a built-in digital thermometer. It can measure capacitance and transistor gain (hFE).

Includes test leads, temperature probe and battery.

Specifications:

DC Voltage: 200 mV, 2 V, 20 V, 200 V, 1000 V;
 $\pm (0.5\% + 1 \text{ digit})$ 10 M Ω input impedance

AC Voltage: 200 mV, 2 V, 20 V, 200 V; $\pm (1\% + 4 \text{ digits})$ 750 V;
 $\pm (1.5\% + 4 \text{ digits})$ 10 M Ω input impedance

DC Current: 200 μ A, 2 mA, 20 mA, 200 mA; $\pm (1\% + 1 \text{ digit})$

AC Current: 200 μ A, 2 mA, 20 mA, 200 mA; $\pm (1.2\% + 4 \text{ digits})$

Capacitance: 20 nF, 200 nF, 2 μ F, 20 μ F, 200 μ F; $\pm (3\% + 10 \text{ digits})$

Resistance: 200 Ω , 2 k Ω , 200 k Ω , 20 M Ω ; for 200 Ω to 200 k Ω $\pm (1.0\% + 4 \text{ digits})$ for 20 M Ω $\pm (2.0\% + 4 \text{ digits})$

Temperature: 4° to 1400°F; 4° to 900°F; $\pm (2.0\% \text{ reading} + 4^\circ\text{F})$;
900° to 1400°F; $\pm (3.0\% \text{ reading} + 4^\circ\text{F})$

Additional Functions: Diode test, transistor hFE, audible continuity test, fold-out stand

Display: 3-1/2 digit LCD display, 17 mm high digits, polarity indication, low battery indication

Power: 200-hour life on 9 V alkaline (battery included)

Drop Resistant**Order Information**

Precision Digital Multimeter,
Component Tester and ThermometerSB-9631B
Replacement Supplies:
Thermocouple Probe.....SB-9632

Voltaic Cell

SE-7249

- Learn how batteries work
- Includes different types of electrodes

Voltaic cell sets are ideal for demonstrating the characteristics of battery cells. This set includes one plastic cell, complete with a screw-on plastic ring, two adjustable electrode holders, a porous ceramic cup, and ten electrodes (aluminum (1), nickel (1), tin (1), graphite (1), iron (1), copper (1), lead (2), and zinc (2)).

Electrolyte is not included.



Order Information

Voltaic Cell..... SE-7249
 Recommended:
 Basic Digital
 Multimeter..... SE-9786A

Genecon Hand Crank Generator

SE-8645



The Genecon Hand Crank Generator produces up to 6 volts DC for basic experiments in electricity, electromagnetism, and electrolysis. It replaces the usual power supply with a device that students can see, operate, and understand.

Order Information

Genecon Hand Crank
 GeneratorSE-8645
 Recommended:
 Capacitor (1.0 Farad)SE-8626
 Light Bulb Sockets (10 pack)EM-8630
 Light Bulbs (#50) 25 pack.....EM-8814

Lightbulbs and Stands

EM-9099



This set of two lamp socket bases includes four #50 miniature screw light bulbs. Great for use with the mini hand-cranked generator.

Order Information

Lightbulbs and Stands EM-9099

Capacitor (1 Farad)

SE-8626



Electrolytic, bipolar, 5 V 1.0 F capacitor. Charge up this capacitor with the Mini Generator and then let go of the crank. The handle will continue to rotate in the same direction as the capacitor discharges.

Order Information

Capacitor (1 Farad) SE-8626

Generators

Energy Transfer – Generator

ET-8771B

- ▶ Transfers gravitational potential energy to electrical energy
- ▶ Open design: 19 mm neodymium magnet can be seen spinning between the two coils
- ▶ Real-time computer measurement of output power

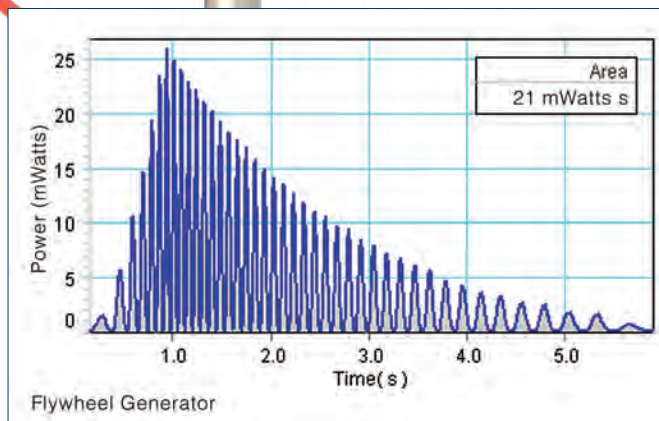
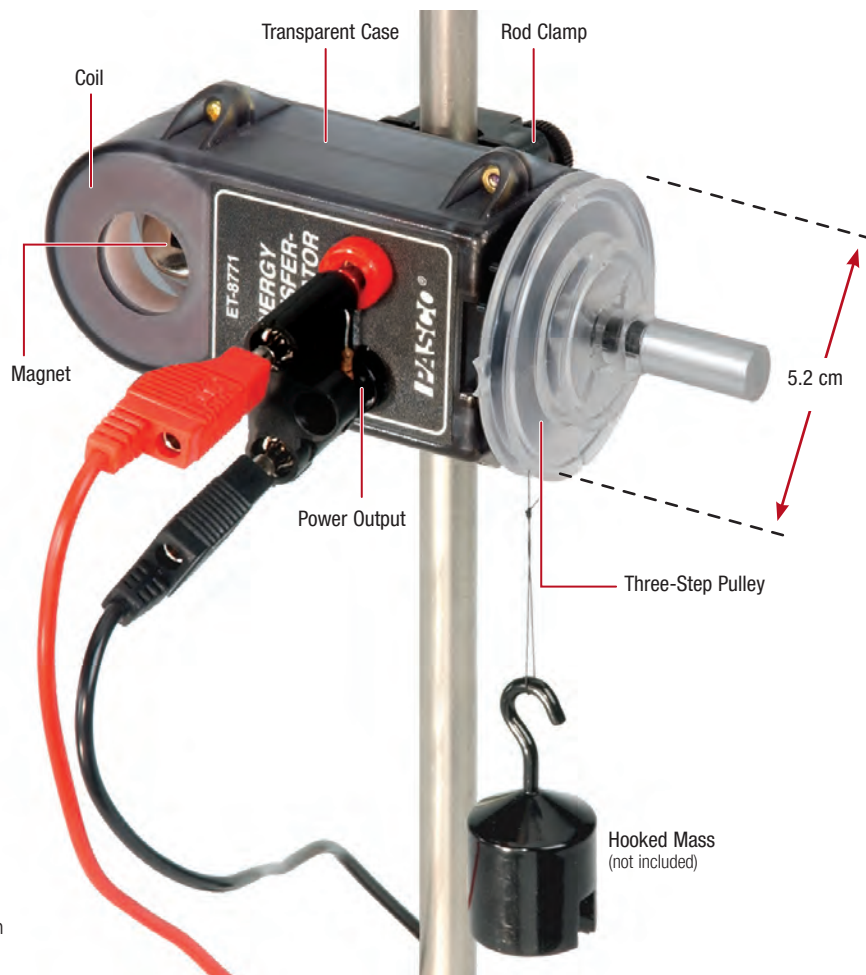
PASCO's Energy Transfer Generator demonstrates the conversion of gravitational potential energy into electrical energy as a falling weight turns a magnet between two coils. The open design permits easy identification of the essential parts of the generator. The supplied lamp or load resistor can be plugged into the output banana jacks. A Voltage Sensor can measure the generated voltage across the load resistor, which can then be used to calculate power generated.

By wrapping the string around different-sized steps on the three-step pulley, the generator will spin at different speeds. The smaller the pulley radius, the slower the weight falls and the greater percentage of the potential energy is converted to electrical energy.

The AC power generated by spinning the shaft by hand easily lights the included red-green LED. The LED goes from red to green, indicating the direction of the current.

The built-in rod clamp is used to mount the generator on a rod stand.

Case Dimensions: 8.7 x 4.4 x 3.6 cm



Order Information

Energy Transfer - Generator	ET-8771B	
Recommended:		
2 Meter Patch Cord Set.....	SE-9415A	p. 248
Energy Transfer - Hydro Accessory.....	ET-8772	p. 253
Hooked Mass Set.....	SE-8759	p. 215
Large Rod Base	ME-8735	p. 204
90 cm Stainless Steel Rod	ME-8738	p. 204
No-Bounce Pad.....	SE-7347	p. 210
Required for use with PASPORT:		
PASPORT Voltage-Current Sensor.....	PS-2115	p. 43

Includes:

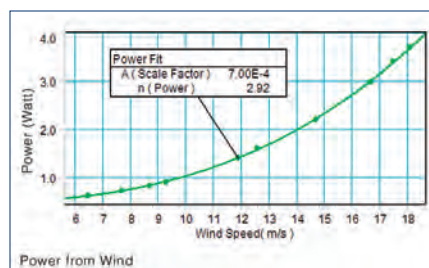
- Generator with three-step pulley
- Red-green LED mounted on plug
- 100-ohm load resistor mounted on plug
- Spool of thread

Energy Transfer – Wind Turbine

ET-8783



Attach this clear propeller to the Energy Transfer Generator for a complete wind energy turbine. Students will better understand the process of electrical energy production from wind after using the turbine.



Includes:

- Fan
- Mounting hardware

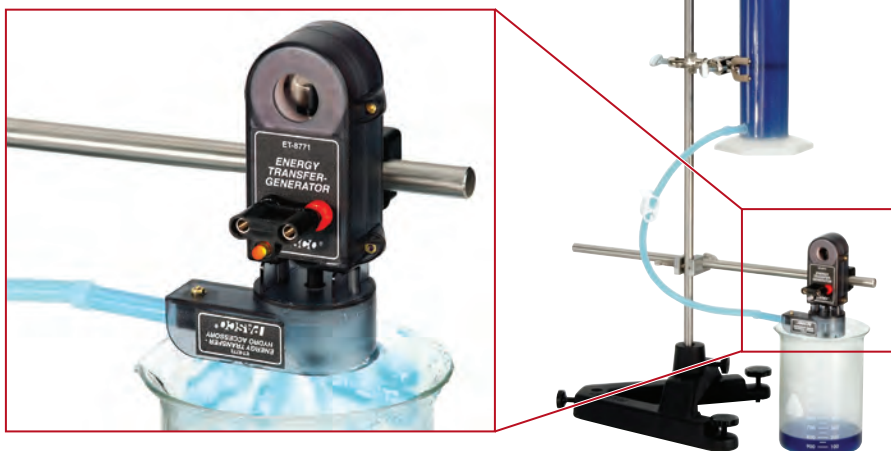
Order Information

Energy Transfer –
Wind Turbine..... ET-8783
Required:
Energy Transfer –
Generator ET-8771B

Energy Transfer – Hydro Accessory

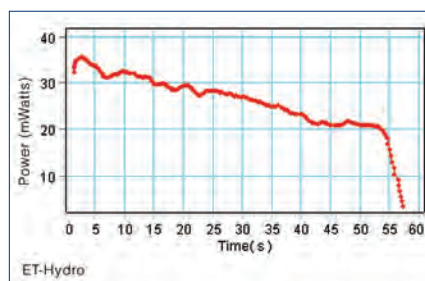
ET-8772

- ▶ Demonstrates hydroelectric power generation
- ▶ Open design gives view of spinning turbine and water stream
- ▶ Falling water lights an LED



The Hydro Accessory is used with the Energy Transfer Generator to demonstrate how falling water generates electricity. The gravitational potential energy of the water is converted into electrical energy as the falling water turns the turbine. The water can be supplied using the optional Water Reservoir. The water that has passed through the turbine is caught in a beaker and measured to determine the total mass that has fallen.

The water nozzle size and angle can be adjusted to optimize performance. By changing the height of the Water Reservoir, different efficiencies are achieved.



Includes:

- Turbine housing
- Plastic turbine (4 cm diameter)
- Water nozzles (5)
- Tubing (2 m long)
- Plastic hose clamp
- Screwdriver for attaching Hydro Accessory to Generator

Order Information

Energy Transfer - Hydro Accessory..... ET-8772
Required:
Energy Transfer - Generator ET-8771B
Recommended:
Water Reservoir ME-8594 p. 213
Large Rod Base ME-8735 p. 204
90 cm Stainless Steel Rod ME-8738 p. 204
Three-Finger Clamp SE-9445 p. 206
Beaker, 1000 mL (6 pack) SE-7288 p. 213

Magnetism

Magnetic Demonstration System

EM-8644B

Demonstrate:

- Magnetic damping
- Diamagnetism and paramagnetism
- Magnetic force on a current-carrying wire swing

This all-in-one demonstration system includes the Variable Gap Magnet (EM-8618) and the Magnetic Force Accessory (EM-8642A).



Includes:

- Variable Gap Magnet
- Pole pieces
- Aluminum paddles (solid, slotted, closed slotted) (3)
- Glass rod
- Aluminum rod
- Wire swing
- Special mounting rod



Demonstrate Magnetic Damping

Swing the solid aluminum paddle through the gap and it stops dead, the motion is damped due to eddy currents. Now try the slotted paddles. One swings freely, while the other is immediately damped.

Demonstrate Diamagnetism and Paramagnetism

The diamagnetic glass rod (Figure a) aligns transverse to the field; the paramagnetic aluminum rod (Figure b) aligns with the field.



(a)



(b)



Demonstrate Force on a Current-Carrying Wire

Pass a current through the wire swing (power supply not included) to investigate the right-hand rule for magnetic forces.

Order Information

Magnetic Demonstration System EM-8644B
(Includes EM-8618 and EM-8642A)

Required:

Genecon Hand Crank Generator SE-8645 p. 251

Base and Support Rod ME-9355 p. 205

Shown in use with:

2 Meter Patch Cord Set..... SE-9415A p. 248

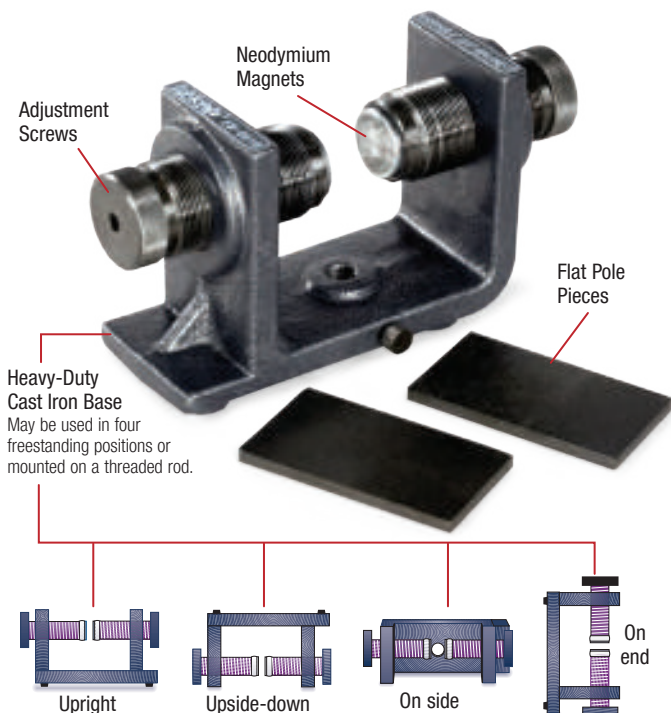
Variable Gap Magnet

EM-8618

- ▶ Lower cost
- ▶ Larger magnets (1 inch diameter)
- ▶ Greater field (1 Tesla maximum)
- ▶ Great for induction experiments

The redesigned Variable Gap Magnet is rugged and durable, while providing excellent results as a demonstration tool. The two one inch (2.54 cm) diameter neodymium magnets are mounted on a heavy-duty cast iron base that has a threaded hole to mount on a support rod, which provides even more versatility.

The gap may be varied from 0.5 cm to 8.9 cm using the adjustment screws. Two flat pole pieces are also included to provide a uniform magnetic field when needed.



Order Information

Variable Gap Magnet.....EM-8618
(Includes Variable Gap Magnet with Pole Pieces)

Magnetic Force Accessory

EM-8642A

Includes:

- Three aluminum paddles (solid, slotted, closed slotted)
- Glass rod
- Aluminum rod
- Wire swing
- Special mounting rod



Order Information

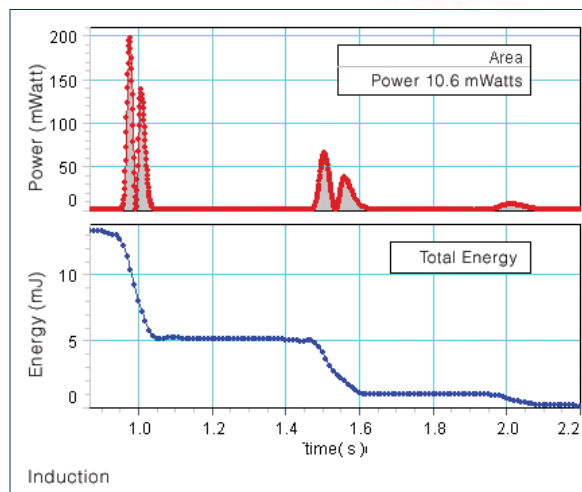
Magnetic Force AccessoryEM-8642A

Induction Wand

EM-8099

See EX-5541A
Faraday's Law of Induction
Experiment on
page 378.

The Induction Wand is a rigid pendulum with a coil at the bottom end connected to the banana terminals at the other end. A through-hole allows the pendulum to be connected to a Rotary Motion Sensor, for detailed investigations of induction as the coil is swung through a magnetic field.



The energy of the pendulum decreases with each pass of the coil through the magnet. The energy dissipated in the resistor is obtained from the area under a Power vs. Time plot.

Includes:

- Wand with screw
- Resistive load



Order Information

Induction WandEM-8099

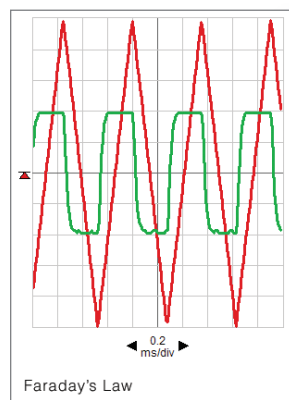
See our
Superconductors
on pages 264-265.



Coils and Cores

Field and Detector Coils

1. EM-6711A Field Coil
200 turns of #22 copper wire,
18.6 cm ID, 22.1 cm OD. Max.
current 2 A.
2. EM-6723A Field Coil
500 turns of #22 copper wire.
Max current 2 A.
3. EM-6712 Detector Coil
400 turns of #28 copper wire.
4. EM-6713 Detector Coil
2000 turns of #36 copper wire.
5. EM-6714 Bi-Color
LED Indicator.



A 5 V triangle wave (red trace) is applied to the Field Coil, and the induced voltage in the 2000-turn Detector Coil is a square wave (green trace).

Features:

- **Verify Faraday's Law:** Verify all aspects of Faraday's Law.
- **Qualitative Demonstration:** With the Bi-Color LED Indicator and the Variable Gap Magnet, students can see when a current is induced in the detector coil. With the LED indicator plugged into a detector coil, the LED flashes red or green as the detector coil passes through the magnet.
- **Quantitative Demonstration:** PASCO's coils can be used with a function generator and an oscilloscope, or connected to the 850 Universal Interface.

Developed for Workshop
Physics® activities.



Activity-Based Learning

For details of experiments using these coils, see Christopher C. Jones, "Faraday's Law Apparatus for the Freshman Laboratory." *Am. J. Phys.* 1987; 55(12):1148-1150.

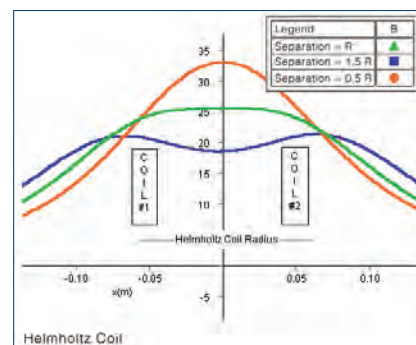


Helmholtz Coils

EM-6722 with 200-turn Coils
EM-6724 with 500-turn Coils



The Helmholtz Coils consist of two coils mounted on a base to provide a uniform magnetic field between the coils. The base has a slot that allows the coils to be spaced apart at any distance from 3 cm to 20 cm (center-to-center distance). The proper separation for Helmholtz coils (i.e., the radius of the coils) is marked on the base. Two 0.635 cm (0.25 inch) diameter holes between the coils accommodate mounting devices in the uniform magnetic field.



This plot shows the magnetic field strength along the axis of Helmholtz coils for three different coil separations: the green data is the magnetic field with the coils separated at the proper distance (the radius of the coils).

Order Information

Field Coil (200 Turn).....	EM-6711A
500-Turn Field Coil	EM-6723A
Detector Coil (400 Turn)	EM-6712
Detector Coil (2000 Turn)	EM-6713
LED Indicator	EM-6714

Recommended:

Variable Gap Magnet.....	EM-8618	p. 253
850 Universal Interface		pp. 20-21
OR		
AC/DC Power Supply.....	SE-9584	p. 271
AND		
Function Generator	PI-8127	p. 274

Order Information

Helmholtz Coil Set, 200 Turn	EM-6722
Helmholtz Coil Set, 500 Turn	EM-6724
Helmholtz Coil Base	EM-6715

Transformer Coils Set

EM-8615



These high-quality coils and laminated iron core provide an effective introduction to electromagnetic induction in transformers. Purchase them individually or as a complete set. Each coil is labeled with the number of turns, the direction of the winding, and the maximum current. Use them to investigate:

- ▶ **Electromagnetism:** Show how the magnetic field can be increased by increasing the current, by adding an iron core, or by using a coil with more turns.
- ▶ **Induction:** Pass a magnet through a coil and detect the resulting electromotive force (EMF) with a galvanometer. Show how the EMF depends on the number of turns in the coil and on the relative velocity of the magnet and coil.
- ▶ **Transformers:** Mount coils onto the U-shaped iron core to demonstrate mutual inductance and transformer theory. Then connect a load to investigate power transfer. Investigate basic transformer theory with an AC power supply and a voltmeter. Advanced principles require a high power output function generator and an oscilloscope. For more in-depth experiments, use a computer with PASCO's 850 Universal Interface or 550 Universal Interface.

Includes:

- Transformer Coil (200 turn) (EM-8609)
- Transformer Coil (400 turn) (EM-8610) (2)
- Transformer Coil (800 turn) (EM-8611)
- Transformer Coil (1600 turn) (EM-8612)
- Transformer Coil (3200 turn) (EM-8613)
- Transformer Core (EM-8614)
- Storage Box



Storage box includes two extra slots for more coils purchased separately.

Order Information

Transformer Coils Set..... EM-8615

Primary/Secondary Coils

EM-6709

These nested primary and secondary coils have a removable soft iron core. Each coil has safety banana jacks. The inner coil has approximately 302 turns of wire and the outer coil has approximately 3077 turns of wire, making the ratio of turns approximately 10:1.

Specifications:

Inner Coil Windings: 302 turns

Outer Coil Windings: 3077 turns

Inner Coil: Inside diameter 10.4 mm, Length 12.3 cm

Outer Coil: Inside diameter 18.1 mm, Length 11 cm

Soft Iron Core: 9.5 mm diameter, 16.5 cm long



Order Information

Primary/Secondary Coils..... EM-6709

Transformer Core

EM-8614

This U-shaped iron core is designed to be used with two coils to form a transformer. The core has laminated iron strips to minimize eddy currents. The cross-bar can be removed to allow the installation of the coils.



Specifications:

Cross-Sectional Dimensions: 1.9 cm x 1.9 cm

U-shape Outside Dimensions: 8.3 cm x 8.3 cm

U-shape Inside Dimensions: 6.3 cm tall x 4.5 cm wide

Cross-Bar Dimensions: 1.9 cm x 1.9 cm x 8.3 cm

Includes:

- U-shaped iron core with cross-bar and clamping screw

Order Information

Transformer Core..... EM-8614

Transformer Coils

EM-8609 200 Turn

EM-8610 400 Turn

EM-8611 800 Turn

EM-8612 1600 Turn

EM-8613 3200 Turn

These high-quality coils are each labeled with the number of turns, the direction of the winding, and the maximum current. These coils are used in the Transformer Coils Set (EM-8615).

Applications:

- ▶ Electromagnetism
- ▶ Induction
- ▶ Transformers



Order Information

Transformer Coil (200 turn) EM-8609

Transformer Coil (400 turn) EM-8610

Transformer Coil (800 turn) EM-8611

Transformer Coil (1600 turn) EM-8612

Transformer Coil (3200 turn) EM-8613

Air Core Solenoid

SE-7585

This Air Core Solenoid has an inner diameter of 5.5 cm and a length of 14.5 cm, allowing ample room to insert an experimental apparatus into its uniform magnetic field. The maximum current of 5 A produces a 125 Gauss magnetic field.



Order Information

Air Core Solenoid SE-7585

Electromagnet

Electromagnet

SE-9655

- Investigate the Zeeman Effect

This electromagnet has a magnetic field strength up to 1.2 T at a maximum current of 5 A. The sturdy base can be rotated and locked into place for viewing perpendicular and parallel to the magnetic field lines. There is a removable iron core that opens a hole through the pole, allowing for viewing parallel to the magnetic field lines. This electromagnet is suitable for the Zeeman Experiment.

Features:

- 1.2 T magnetic field strength at 5 A
- Approximately 7.4 mm pole gap
- Swivel Base
- Hole in pole allows viewing parallel to the axis of the magnetic field

Specifications:

Maximum Magnetic Field Strength: 1.2 T

Maximum Current: 5 A

Pole Gap: Approximately 7.4 mm



This electromagnet provides a magnetic field strength up to 1.2 T for the Zeeman Experiment.



Removing the core allows viewing parallel to the magnetic field axis.

Order Information

Electromagnet SE-9655

Recommended:

Tunable DC Power Supply 6A SE-9656

Magnetic Field Meter SE-7579B

p. 271

p. 268

Ring Launcher with Accessories

EM-8817

- ▶ Electromagnetic induction
- ▶ Shoots ring 2 meters high
- ▶ Improved design with thermal shutoff

This Ring Launcher has been optimized to maximize safety by enclosing all wiring inside the case. A thermal shutoff switch protects the coil by preventing overheating.

Includes a coil with a bulb that lights by induction when the coil is placed over the launcher core. Also includes five rings: one split aluminum ring that will not launch, one copper ring, one shorter aluminum ring, and two regular length aluminum rings.

A classic demonstration

In this demo, an aluminum ring is propelled straight up by the Lorentz force that arises from the interaction between the alternating magnetic field of the coil and the current induced in the ring.

For great demo ideas using the PASCO Ring Launcher, check out James Lincoln's AAPT video. James explains how the Ring Launcher works and walks you through all the classic demonstrations.



Ring Launcher design ideas contributed by Carl Schneider and John Ertel from the U.S. Naval Academy.



Includes:

- Launcher
- Coil with Light Bulb
- Split Aluminum Ring
- Aluminum Ring (2)
- Short Aluminum Ring
- Copper Ring



Overheat Light

Lighting a bulb connected to a coil by induction; coil and bulb are included in Ring Launcher Accessories.

Order Information

Ring Launcher with Accessories.....	EM-8817
Also available:	
Ring Launcher	EM-8661
Replacement:	
Ring Launcher Accessories	EM-8662

Electron Charge

Millikan Oil Drop Apparatus

AP-8210B

- ▶ Nobel Prize-quality physics in the student lab
- ▶ Ionization source for changing droplet charge
- ▶ Measures the charge of an electron to within $\pm 3\%$

The Millikan Oil Drop Experiment is one of the most popular experiments in undergraduate physics for several reasons:

- ▶ The experimental principle is straightforward and easy to understand.
- ▶ It measures a fundamental atomic constant using a method that won its originator, Robert Millikan, the Nobel Prize.
- ▶ 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 electricity.

See complete experiment on page 369.



The Millikan Oil Drop Apparatus mounted on a rod stand for easy, eye-level viewing.

Specifications:

Maximum Plate Voltage: 500 VDC

Light Source: Cool LED

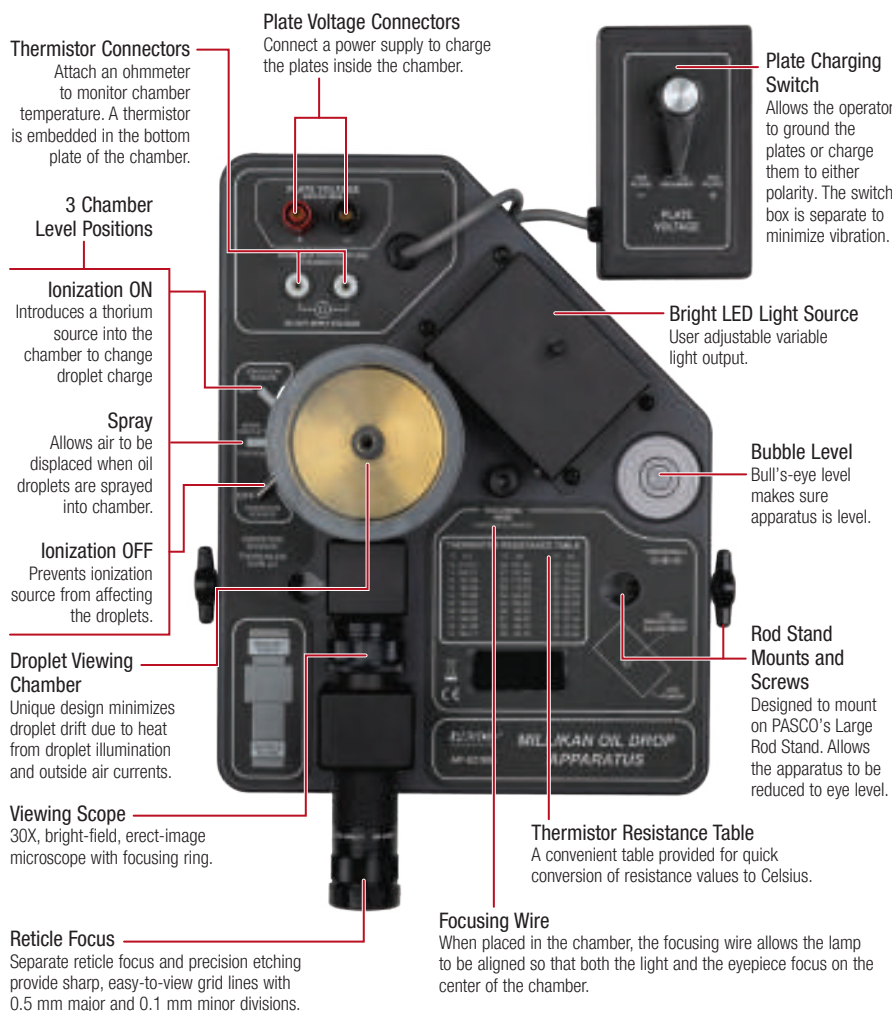
Reticle Line Separation:

0.5 mm major divisions

0.1 mm minor divisions

Plate Spacing: 7.62 mm

Plate Diameter: 60 mm



Includes:

- Millikan Oil Drop Apparatus with Switch
- Non-volatile Oil and Atomizer
- 12 VDC Lamp Power Adapter

Order Information

Millikan Oil Drop Apparatus	AP-8210B	
Required:		
Basic Digital Multimeter	SE-9786A	p. 269
High Voltage DC Power Supply	SE-9700	p. 273
Recommended for mounting unit at eye level on a standard lab table:		
Large Rod Base	ME-8735	p. 204
45 cm Stainless Steel Rod	ME-8736	p. 204
Replacement Parts:		
4 oz Bottles of Mineral Oil (Qty 4)	AP-8211	
Millikan LED Light Source	AP-8212	

Clear droplet observation and low droplet drift are essential for success with Millikan's classic experiment. PASCO's apparatus uses a pre-aligned optical system and special condenser to achieve these conditions.

Accuracy in the Oil Drop Experiment depends on the student's ability to precisely measure all the variables involved: plate voltage, plate separation, time and distance of droplet rise and fall, temperature, oil density, etc. Extreme care taken in the design and manufacturing of this unit ensures that the student's best efforts will be rewarded with more accurate results. Typically, a careful student can achieve results within 3% or less of the accepted value.

e/m Apparatus

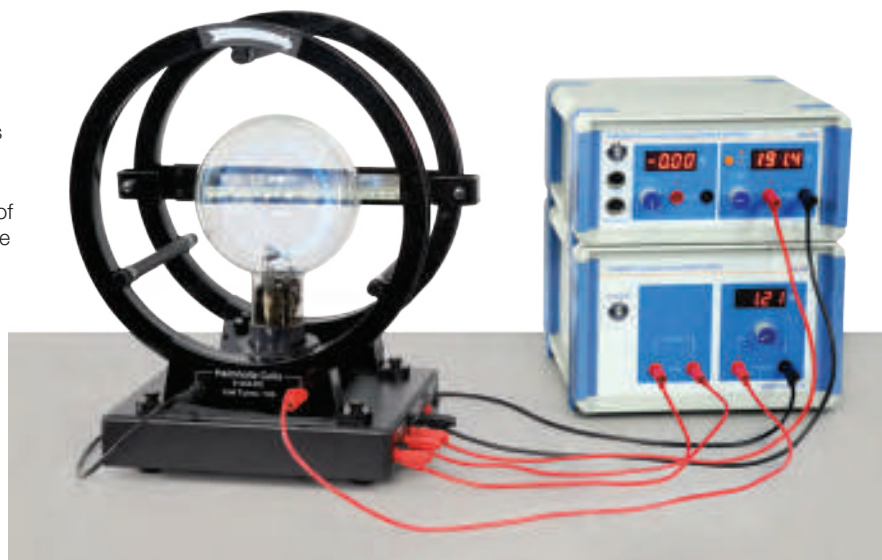
SE-9629

- ▶ Sharp, clearly visible electron beam
- ▶ Phosphorescent mirrored scale eliminates parallax errors
- ▶ Tube rotates for general study of electrons in a magnetic field

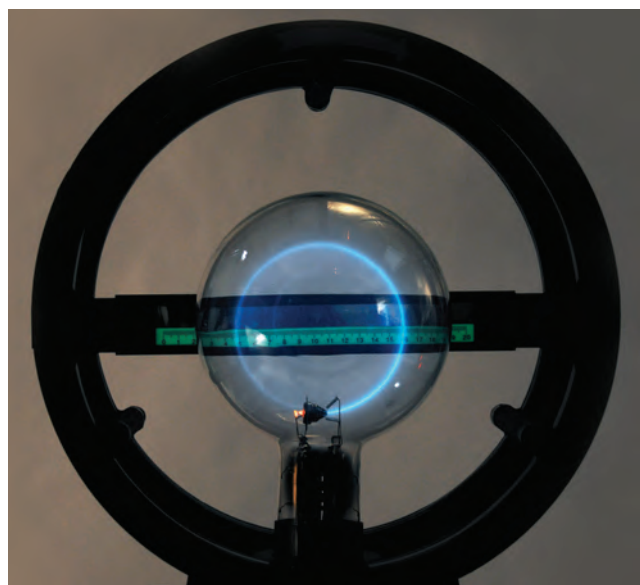
In 1897, J. J. Thomson showed that the mysterious cathode rays were actually negatively charged particles—he had discovered the electron. In the same year he measured the charge-to-mass ratio of the electron, providing the first measurement of one of the fundamental constants of the universe.

The Charge-to-Mass Ratio System reproduces one version of Thomson's landmark experiment, providing an accurate measurement of the charge-to-mass ratio of the 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.

This apparatus also has deflection plates, so students can study the effect of an electric field on moving electrons.



The complete Charge-to-Mass Ratio System includes the power supplies, which can also be used in other experiments (such as the Franck-Hertz experiment, see page 404).



Fluorescent scale is clearly visible behind the electron beam in a dark room.

Includes:

- Helmholtz Coils for e/m (SE-9626)
- Replacement e/m Tube (SE-9651)
- Tunable DC Power Supply (Constant Current) (SE-9622)
- DC Power Supply II (Constant Voltage) (SE-9644)
- Red and Black Patch Cords

For more information
about power supplies,
see page 270.

How It Works

A large, helium-filled electron tube is mounted between a pair of Helmholtz coils. The tube contains an electron gun, which generates a focused beam of electrons. A measured current is applied to the Helmholtz coils so that the magnitude of the magnetic field within the electron tube can be calculated. A measured accelerating potential (V) is then applied to the electron gun. The magnetic field (B) deflects the electron beam in a circular path with a radius (r) that is measured using the illuminated mm scale. From these measured values, the charge-to-mass ratio of the electron is calculated:

$$e/m = 2V/B^2r^2.$$

(The details of the calculations are fully described in the manual.)

Specifications:

Helmholtz Coil Radius: 16 cm

Number of Turns: 130

Maximum Current: 3.5 A

Filament Voltage: 6.3 VAC

Acceleration Voltage: 0–200 V

Tube Diameter: 15.5 cm

Order Information

e/m Apparatus	SE-9629
If you already have power supplies, you will need:	
Helmholtz coils for e/m	SE-9626
e/m Tube	SE-9659

Ampere's Law

Ampere's Law Accessory

EM-6720

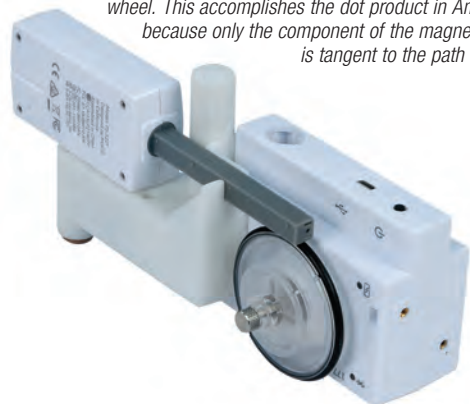
- Verify Ampere's Law
- Plot magnetic field tangent to path
- Closed integral is area under B vs. Distance plot
- Choose to enclose current in path or not

Students can verify Ampere's Law experimentally by graphing the magnetic field strength that is tangent to the path taken along a closed path that encloses a current source.

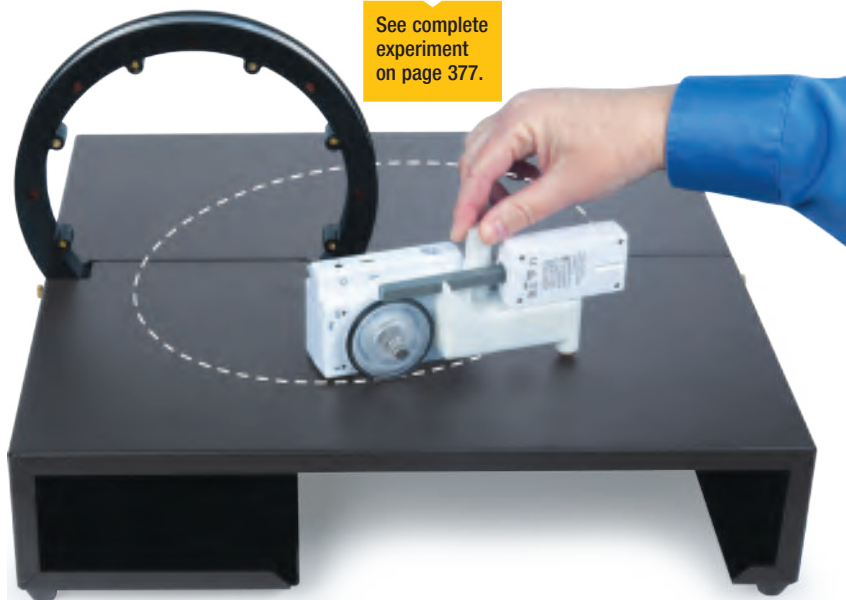
The magnetic field strength is measured with a Wireless Magnetic Field Sensor which rides on a Rotary Motion Sensor. The student pushes the Rotary Motion Sensor, which rolls on its wheel, along a closed path.

If you traverse a path that does not enclose any current source, the area under the curve is zero. The magnetic field of the Earth or any nearby source is measured, but they will cancel out in a closed loop that encloses no current.

The key to making this work is that the Magnetic Field Sensor element is positioned tangent to the Rotary Motion Sensor's wheel. This accomplishes the dot product in Ampere's Law because only the component of the magnetic field that is tangent to the path is recorded.



See complete experiment on page 377.

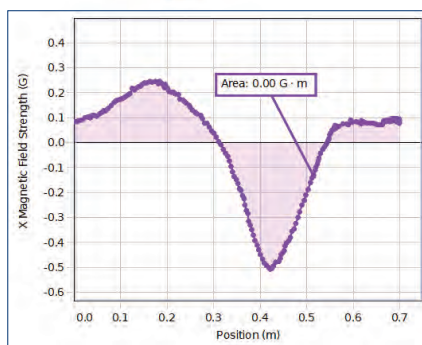


The Wireless 3-Axis Magnetic Field and Rotary Motion sensors allow students to move in any shaped path without wires getting wrapped around the coil. Students can choose any path they want; you don't have to follow a circular path because the sensors are recording the field tangent to any path.

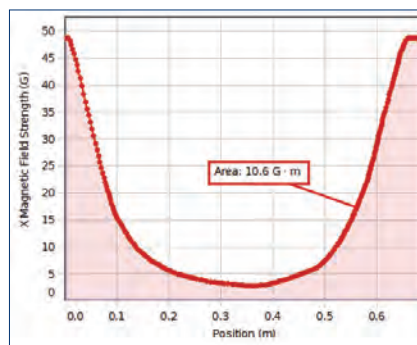
Ampere's Law

$$\oint \vec{B} \cdot d\vec{l} = \mu_0 NI$$

Area under B vs. Distance curve = μ_0 (# of coil turns enclosed in path) (Current)



No current enclosed: Area is zero.



Current enclosed: Area is $\mu_0 NI$.

Includes:

- Aluminum Table (46 cm x 46 cm x 11 cm)
- Sensor Bracket



Order Information

Ampere's Law Accessory	EM-6720	
Required:		
Wireless Magnetic Field Sensor	PS-3221	p. 64
Wireless Rotary Motion Sensor	PS-3220	p. 53
500-Turn Field Coil	EM-6723A	p. 256
PASCO Capstone Software		p. 8-11

Current Balance

EM-8607

The Current Balance measures the force on a current-carrying wire in a magnetic field:

$$\text{Force} = (\text{current})(\text{length})(\text{magnetic field})$$

In this apparatus, the current-carrying wire is perpendicular to the magnetic field. The current, wire length, and magnetic field strength can be varied.

A wire of a certain length (mounted on a circuit board) is positioned between the poles of a horseshoe magnet, resting on a mass balance. When a current runs through the wire, the force of the current on the magnet registers on the balance.

There are four different length wires (2 cm, 3 cm, 4 cm, and 5 cm), each mounted on a separate circuit board, so the relationship between wire length and magnetic force can be determined.

The magnetic field strength can be varied by removing each of the five horseshoe magnets one by one. The magnetic field remains uniform across the length of the wire because of the pole pieces in the magnet holder. The magnetic field strength can be measured with a Wireless Magnetic Field Sensor (PS-3221).

These experiments require a mass balance that will measure to 0.01 grams and a DC power supply that will supply current up to 6 amps.

Specifications:

Individual Horseshoe Magnets:

3 cm x 1.2 cm x 1 cm high;
About 220 gauss at pole

Aluminum Magnet Holder:

3 cm x 4 cm x 8 cm

Wire Lengths:

2, 3, 4, and 5 cm long

Maximum Current: 8 A

Circuit Board Holder:

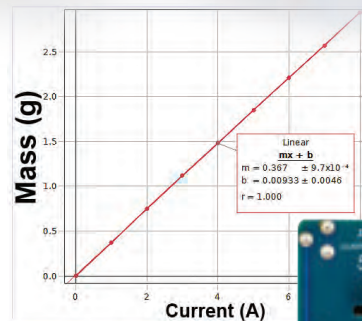
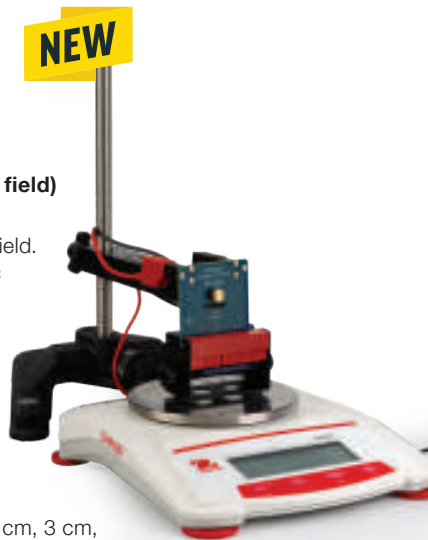
Fits 0.5-inch (13 mm) rods

Typical Forces:

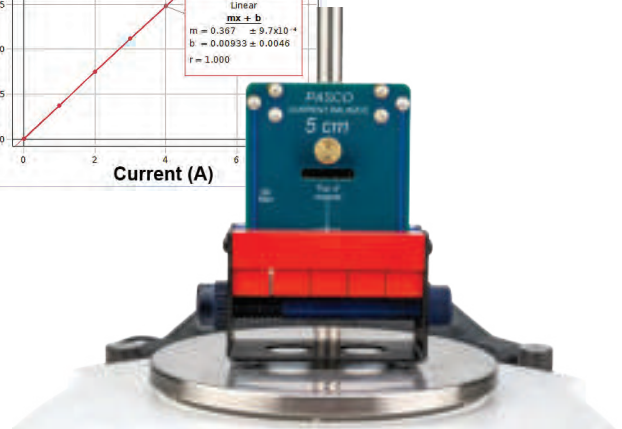
4 mN (0.4 g) to 20 mN (2 g)

Magnetic Field Range:

Approximately 20 mT to 70 mT



The mass read on the balance versus the current through the wire.



Close-up of the 3-cm long wire.

Perform These Experiments:

- Vary the current through a wire in the gap of a magnet and measure the resulting force experienced by the magnet.
- Vary the length of a current-carrying wire in the gap of a magnet and measure the resulting force experienced by the magnet.
- Vary the number of magnets in an assembly of U-shaped magnets and measure the resulting force experienced by current carrying wire in the gap.

Order Information

Current Balance.....	EM-8607	
Required:		
Ohaus Cent-O-Gram Balance.....	SE-8725	p. 212
AC/DC Power Supply.....	SE-9584	p. 271
Base and Support Rod.....	ME-9355	p. 205
Recommended:		
Basic Digital Multimeter.....	SE-9786A	p. 250
Magnetic Field Meter.....	SE-7579B	p. 268
Shown in use with:		
2 Meter Patch Cord Set.....	SE-9415A	p. 248



Includes:

- Horseshoe Magnets (5)
- Magnet Holder
- Wire Boards (4)
(2 cm, 3 cm, 4 cm, 5 cm wire lengths)
- Wire Board Holder

Superconductivity

Superconductor Magnetic Levitation

These high-temperature superconductors conduct electricity without energy loss when cooled to liquid nitrogen temperature (77 K). Because a superconductor expels external magnetic fields by forming surface currents, which cancel the external field, it will levitate above a magnet.

Mini MagLev Pro

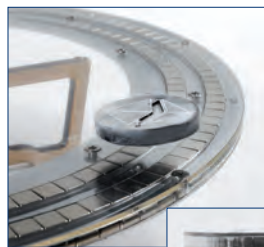
SE-7720



- Demonstrate superconducting levitation
- Levitating superconductor glides around the circular magnetic track



Experience Quantum Levitation with this portable, lightweight, and easy-to-use MagLev track. The track uses super-strong NdFeB magnets in a unique double-ring design to achieve maximum levitation height. The included handheld magnetic device (Starter Kit) can be passed around for a captivating hands-on experience. Please note that this product requires liquid nitrogen.



Demonstrate frictionless motion in both levitation and suspension.

Includes:

- Round MagLev track (diameter 40 cm, 15.7 in)
- Wooden stand
- Medium Standard Superconductor
- Medium Enhanced Superconductor
- MagLev Starter Kit
- User manual

Order Information

Mini MagLev Pro..... SE-7720
 Required:
 Liquid Nitrogen
 Recommended:
 Wireless Force
 Acceleration Sensor PS-3202

Magnetic Levitation

SE-7721

- Perfect for large science demonstrations
- Undergraduate and high school experiments in quantum physics
- Science museums



The 72 cm diameter Magnetic Levitation kit is perfect for large audience demonstrations at science museums, science fairs and student classes. The circular frictionless motion never ceases to amaze. The kit is supplied with large and medium Quantum Levitators, which can be levitated simultaneously in a double levitation configuration. Both suspension below the track and levitation above it can be demonstrated. A handheld magnetic device (MagLev Starter Kit) is included for a complete experience. Please note that this product requires liquid nitrogen.

Includes:

- Round MagLev Track (diameter 72 cm, 28 in)
- Stand
- Standard Medium and Large Superconductors
- MagLev Starter Kit
- User and experiment manual

Order Information

Magnetic Levitation SE-7721
 Required:
 Liquid Nitrogen
 Recommended:
 Wireless Force
 Acceleration Sensor PS-3202

MagLev Starter Kit

SE-7732



The MagLev Starter Kit is the most fundamental entry level for classroom demonstrations of quantum levitation and flux pinning. Perfect for high school students as well as university undergraduates, the kit is easy to use, highly durable and portable. Use the rectangular magnetic setup to witness the quantum locking phenomena and the round magnetic setup to demonstrate frictionless motion. When used with a force sensor, the handheld magnetic device serves as a unique experimentation platform where quantum phenomena such as the Meissner effect and flux pinning can be investigated. Please note that this product requires liquid nitrogen.



Includes:

- Standard Medium Superconductor
- Starter Magnetic Kit
- Plastic tweezers
- User manual

Order Information

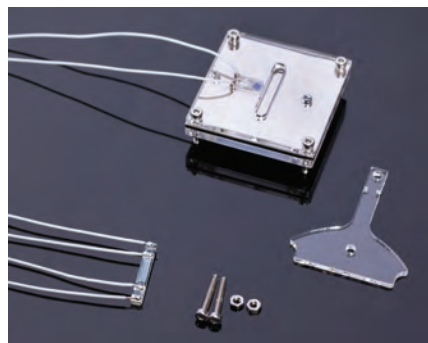
MagLev Starter Kit SE-7732
 Required:
 Liquid Nitrogen
 Recommended:
 Wireless Force
 Acceleration Sensor PS-3202

4-Point Wired Superconductor

SE-7734



Measuring the transition temperature of superconductors is one of the basic and most educational experiments in superconductivity and is now available to students with an easy and instructive experiment that is on par with state-of-the-art scientific research. The 4-Point Wired Superconductor includes a superconducting Bi-2223 bar with four wires attached to it. Students can experiment with 4-wire and 2-wire resistance measurements and learn how to measure the critical temperature of superconductors. The superconductor is thermally attached to a metallic plate to which a Pt100 resistance thermometer is also attached. Please note that this product requires liquid nitrogen.



Includes:

- Replaceable Bi-2223 superconductor bar with attached 4-wire set
- Thermal base with Pt100 RTD thermometer
- Perspex® handle
- User manual

Order Information

4-Point Wired Superconductor SE-7734

Required:
Liquid Nitrogen

MagLev Outreach Set

SE-7733



QUANTUM LEVITATION

This is the ultimate outreach package for quantum levitation and quantum locking. This set contains portable, easy-to-use experiments that can be used outside the lab and allow a hands-on experience with quantum levitation. Please note that this product requires liquid nitrogen.



Includes:

- Round MagLev track (diameter 40 cm, 15.7")
- Wooden stand
- DIY MagRail track
- Handheld magnetic device
- Standard Superconductors (2 medium, 1 large)
- Plastic tweezers
- User manual

Order Information

MagLev Outreach Set SE-7733

Required:
Liquid Nitrogen



Powered by
THEVA
www.theva.com



Superconducting Levitators

These superconducting levitators are easy to use and highly durable.

They are provided with a 6 month, no-questions-asked warranty.

Standard Superconductors

The Standard Superconductors are able to carry only their own weight plus liquid nitrogen.

Enhanced Superconductors

The Enhanced Superconductors, having extra superconducting material, are able to carry a light weight (< 200 g) when used in conjunction with a suitable magnetic setup or track.

Extended Duration Superconductors

The Extended Duration Superconductors offer the optimal balance between levitation strength and levitation time. These new levitators offer two- to three-times longer levitation times compared to the standard ones.

Order Information

Standard Medium Superconductor	SE-7735
Standard Large Superconductor	SE-7736
Enhanced Medium Superconductor	SE-7737
Enhanced Large Superconductor	SE-7738
Extended Duration Medium Superconductor	SE-7741
Extended Duration Large Superconductor	SE-7742

Magnetism Supplies

Bar Magnets (2 pack)

SE-8604



These cylindrical magnets (10 x 50 mm) are small, strong, and color-coded for polarity. Plastic case and keeper plates included.

Order Information

Bar Magnets (2 pack) SE-8604

Alnico Bar Magnets (2 pack)

EM-8620



These magnets (150 x 13 mm) are stronger and last longer than iron magnets. They fit a St. Louis motor and the north poles are notched. Case included.

Order Information

Alnico Bar Magnets (2 pack) EM-8620

Painted Bar Magnet (pair)

SE-7593

This pair of AlNiCo bar magnets are perfect for studies of magnetism, magnetic polarity, and magnetic field strength. Both magnets are coated with red and blue paint, each color indicating the polarity of that part of the magnet.

Specifications:

Dimensions: 75 mm x 11.2 mm x 6.1 mm**Material:** AlNiCo

Cow Magnet (pair)

SE-7722



These strong, smooth magnets are convenient for showing magnetic induction by moving one through a coil connected to an ammeter. As the name suggests, the primary purpose of these magnets is to collect metal objects in a cow's first stomach to prevent internal damage.

Length: 7.5 cm

Field Strength:

1400 gauss at pole surface

Order Information

Cow Magnet (pair) SE-7722

Zero Gauss Chamber

EM-8652



This double-walled, high permeability metal chamber produces a zero gauss field within the chamber. By placing the Magnetic Field Sensor probe into the chamber and pushing the "Tare" button, the sensor may be zeroed. Highly recommended for measurement of Earth's magnetic field.

Order Information

Zero Gauss Chamber EM-8652

Neodymium Magnets, (16 pack, solid)

EM-8648B

Neodymium magnets are some of the strongest commercial magnets available. This set is also available with a protective coating to prevent the brittle metal from chipping (EM-8621).

Size: 13 mm dia. x 5 mm

Plastic case included.



WARNING

This product contains small magnets. Swallowed magnets can stick together across intestines causing serious infections and death. Seek immediate medical attention if magnet(s) are swallowed or inhaled.

Order Information

Neodymium Magnets, (16 pack, solid) EM-8648B

Single-color Bar Magnets

SE-7726

This pair of Alnico bar magnets is perfect for studies of magnetism, magnetic polarity, and magnetic field strength. Both magnets are coated with only red paint to help avoid polarity misconceptions.

Specifications:

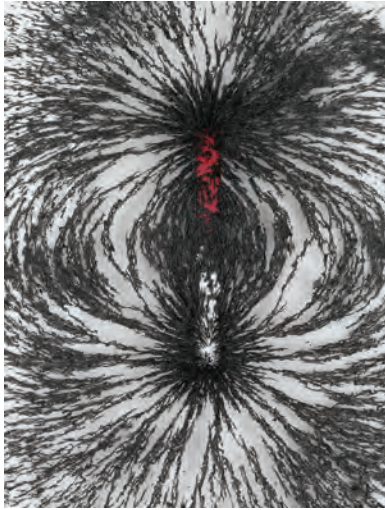
Dimensions: 4 x 0.5 x 0.25 in

Order Information

Single-color Bar Magnets SE-7726

Iron Filings (1 lb)

SE-7723



Iron filings sprinkled over a bar magnet instantly make the magnetic field visible.

**Order Information**

Iron Filings (1 lb) SE-7723

3-D Magnetic Field Demonstrator

SE-8603



(Magnet not included.)

The 3-D Magnetic Field Demonstrator suspends iron filings in oil within a sealed acrylic container. Magnet(s) are inserted into the 10 mm opening, causing the filings to create magnetic field lines. The demonstration can be viewed directly or with an overhead projector.

Order Information

3-D Magnetic Field DemonstratorSE-8603
Recommended:
Bar Magnets (2 pack).....SE-8604 p. 266

Liquid-Filled Compasses (5 pack)

EM-8631A



This compass is perfect for investigating the magnetic fields around straight wires. It has a 4.5 cm diameter liquid-filled plastic case and a 2.5 cm long needle with the north end marked in red.

Order Information

Liquid-Filled Compasses (5 pack) EM-8631A
Replacement part for CASTLE Kits (EM-8624A and EM-8654)

Plotting Compass Set (20 pack)

SE-8680



(Appearance may vary.)

This Plotting Compass provides an economical way to conduct magnetism labs. Includes 20 compasses marked in red with North-South and East-West lines. Students can place several compasses around a bar magnet and draw the magnetic field lines. Each compass has a diameter of 19 mm.

**Order Information**

Plotting Compass Set (20 pack)SE-8680

Magnaprobe

SE-7390



The Magnaprobe is a great way to demonstrate the 3-D nature of magnetic fields. The probe features a gimbal-mounted Alnico magnet, which is free to move in the x, y, and z dimensions. Suggested activities are included with each probe.

Magnaprobe is 12 cm long.

**Order Information**

Magnaprobe SE-7390

Magnetism Supplies

Magnetic Field Meter

SE-7579B

This Hall Effect sensor measures AC and DC magnetic field strength.



Features:

- ▶ AC and DC magnetic field measurements
- ▶ Measures up to 3 T
- ▶ Hall Effect sensor with temperature compensation
- ▶ Sensitivity on lower scale 0.1 G
- ▶ North and South pole indication
- ▶ Zero button
- ▶ Auto power off
- ▶ LCD display
- ▶ Data hold and min/max record-recall
- ▶ Choice of gauss or mT units

Specifications:

DC Measurement Ranges:

300.00 mT (0.01 mT resolution);
3000.0 mT (0.1 mT resolution)

AC Measurement Ranges:

150.00 mT (0.01 mT resolution);
1500.00 mT (0.1 mT resolution)

Accuracy at 23°C: $\pm 5\%$ of reading

AC Frequency Response: 50 Hz/60 Hz

Display Sampling Time: Approx. 1 second

Operating Temperature: 0 to 50°C

Power Supply: 9 V battery
(AC adapter included)

Mass: 275 g with probe

Meter Dimensions: 198 x 68 x 30 mm

Probe Dimensions: 195 x 25 x 19 mm

Probe Tip Thickness: 1.8 mm

Includes:

- Magnetic Field Meter
- Uniaxial Probe Sensor with Protective Cover
- 9 V Battery
- Universal AC Adapter (9 V, 1 A)
- Hard Carrying Case



Order Information

Magnetic Field MeterSE-7579B

Dip Needle/Oersted's Apparatus

SE-8619



Find the dip angle of the Earth's magnetic field.

This dual-purpose apparatus can be used as a dip needle or Oersted's apparatus.

- Find the dip angle of the Earth's magnetic field at your location by aligning the horizontal compass needle with the Earth's magnetic field. Then rotate it to the vertical to show the angle at which the Earth's magnetic field points into or out of the horizontal plane.
- Demonstrate that a current loop produces a magnetic field. With the compass needle aligned with the Earth's field in the horizontal plane, connect a DC power supply to the banana jack terminals on the apparatus to run a current through the conducting aluminum loop that forms the frame that holds the compass needle. The compass needle will deflect in response to the magnetic field created by the current loop.



Apply a voltage to run a current through the conducting loop to show that the current produces a magnetic field.



Includes:

- Compass needle
- Rotatable stand

Order Information

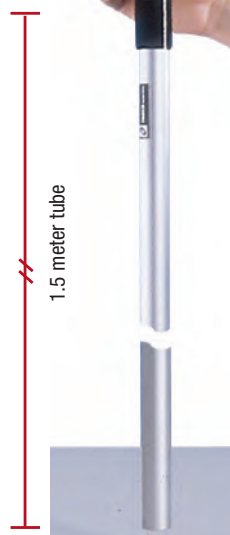
Dip Needle/
Oersted's Apparatus SE-8619

Lenz's Law Demonstrator

MG-8600



Magnet 6 cm long
19.8 mm OD



Drop a mass through the 1.5 m tube. It takes about half a second to drop. Then drop a magnet with an identical mass. It takes over 10 times as long to fall. As the magnet falls, it generates a current in the tube, moving in one direction above the magnet and in the opposite direction below. Both currents obey Lenz's Law and induce magnetic fields that oppose the magnet's motion. See the difference in time as the magnet falls through the tube.

Includes:

- Lenz's Law Magnet
- Unmagnetized Slug
- 1.5 m Aluminum Tube (2 cm ID, 0.28 cm wall)
- 10-turn Rectangular Coil
- Attachment Bracket for Spring Scale
- Ohaus Spring Scale 10N

Order Information

Lenz's Law DemonstratorMG-8600

Decade Capacitance Box

SE-8689

This Decade Capacitance Box supplies five decades of capacitance from 100 pF to 11.111 μ F in 100 pF steps. Add or subtract capacitance with slide switches.

Three color-coded binding posts provide reliable connections.

Specifications:

Accuracy: $\pm 5\%$ **Maximum Voltage:** 50 VDC

Order Information

Decade Capacitance Box SE-8689

Precision Digital Multimeter, Component Tester and Thermometer

SB-9631B



This is an excellent general purpose multimeter that features high-accuracy overload protection on all ranges and a built-in digital thermometer. It can measure capacitance and transistor gain (hFE).

Specifications:

DC Voltage: 200 mV, 2 V, 20 V, 200 V, 1000 V; $\pm (0.5\% + 1 \text{ digit})$ 10 M Ω input impedance**AC Voltage:** 200 mV, 2 V, 20 V, 200 V; $\pm (1\% + 4 \text{ digits})$ 750 V; $\pm (1.5\% + 4 \text{ digits})$ 10 M Ω input impedance**DC Current:** 200 μ A, 2 mA, 20 mA, 200 mA; $\pm (1\% + 1 \text{ digit})$ **AC Current:** 200 μ A, 2 mA, 20 mA, 200 mA; $\pm (1.2\% + 4 \text{ digits})$ **Capacitance:** 20 nF, 200 nF, 2 μ F, 20 μ F, 200 μ F; $\pm (3\% + 10 \text{ digits})$ **Resistance:** 200 Ω , 2 k Ω , 20 k Ω , 20 M Ω ; for 200 Ω to 200 k Ω $\pm (1.0\% + 4 \text{ digits})$ for 20 M Ω $\pm (2.0\% + 4 \text{ digits})$ **Temperature:** 4° to 1400°F; 4° to 900°F; $\pm (2.0\% \text{ reading} + 4^\circ\text{F})$; 900°F to 1,400°F; $\pm (3.0\% \text{ reading} + 4^\circ\text{F})$ **More specifications at pasco.com**

Order Information

Precision Digital Multimeter, Component Tester and Thermometer SB-9631B

Replacement Supplies

Thermocouple Probe SB-9632

Decade Resistance Box

SE-7124



Resistance is plainly displayed with this six-decade resistance box since a rotary switch selects the resistance within each decade. With 1% accuracy and 1/2 W resistor, it will accommodate most student experiments.

Specifications:

Resistance:0 to 1, 111, 110 Ω in 1 Ω increments**Accuracy:** $\pm 1.0\% \pm 0.1 \Omega$ **Power Dissipation:** 1/2 W resistors

Order Information

Decade Resistance Box SE-7124

Basic Digital Multimeter

SE-9786A

This basic meter includes all the functions and ranges needed for most introductory lab work.



Features:

- ▶ 10 amp range
- ▶ Backlit display with 25 mm digits
- ▶ Soft rubber boot for drop protection
- ▶ Built-in tilt stand
- ▶ Type K thermometer built in for surface or air measurements
- ▶ Auto power off saves battery life

Specifications:

DC Voltage: 0.1 mV to 600 V with $\pm 0.5\%$ accuracy**AC Voltage:** 1 mV to 600 V with $\pm 0.3\%$ accuracy**DC Current:** 0.1 μ A to 10 A**AC Current:** 0.1 mA to 10 A**Resistance:** 0.1 Ω to 20 M Ω **Additional Functions:** Input fuse protection, audible and visible misconnection signals, data hold freezes display reading**Display:** 3-1/2 digit display with 25 mm digits, polarity indication, low battery indication**Power:** 9 V battery (included)

Order Information

Basic Digital Multimeter SE-9786A

Digital LCR Meter

SE-8792A

Measure inductance, capacitance, and resistance with this Digital LCR Meter. Test leads are included, along with a battery, a protective holster, and a manual.



Features:

- ▶ **Accuracy:** 1% or better on most ranges
- ▶ **Easy to Use:** Push-button selection for all measurements
- ▶ **Built-in Tilt Stand:** For convenient tabletop use
- ▶ Measures Inductance, Capacitance, and Resistance with secondary parameter Q (Quality), D (Dissipation), R (Resistance), P (Phase), ESR (Equivalent Series Resistance)
- ▶ Simultaneous 20,000/2,000 count backlit display of the primary parameter (L, C or R) with the secondary parameter
- ▶ Auto Select measurement function with 1 kHz default test frequency
- ▶ Five test frequencies
- ▶ Set Hi/Lo limits using absolute values or percentage limits
- ▶ Relative mode function
- ▶ Parallel or Series equivalent circuit
- ▶ Auto power off, low battery and overrange indicators
- ▶ Open and Short calibration removes unwanted stray impedances from the measurement

Specifications:

Inductance: 20 μ H, 200 μ H, 2000.0 μ H, 20.0000 mH, 200.00 mH $\pm (0.5\% \text{ rdg} + 5 \text{ digits})$; 2000.0 mH, 20.000 H, 200.00 H, 2000.0 H (DF < 0.1)**Capacitance:** 20 pF, 200 pF, 2000 pF, 20.000 nF, 200.00 nF, 2000.0 nF $\pm (0.5\% \text{ rdg} + 5 \text{ digits})$; 20.000 μ F, 200.00 μ F, 2.0000 mF, 20.00 mF (DF < 0.1)**Resistance:** 20.00 Ω , 200.00 Ω , 2.0000 k Ω , 20.000 k Ω , 200.00 k Ω , 2.0000 M Ω , 20.000 M Ω , 200.0 M Ω $\pm (0.5\% \text{ rdg} + 5 \text{ digits})$ **Test Frequency:** 100 Hz, 120 Hz, 1 kHz, 10 kHz, 100 kHz**Power:** 9 V alkaline battery (included)**Accessories:** Test leads (2), alligator clips (2), protective holder

Order Information

Digital LCR Meter SE-8792A

Power Supplies

Power Supplies and a Current Amplifier for Advanced Physics Experiments

The power supplies and instruments on this page are used in various advanced physics experiments involving finding fundamental constants (Photoelectric Effect, Franck-Hertz, and e/m). Since each experiment uses some combination of these, it is possible to purchase one of each to perform all three experiments, one at a time.

Connect to a 550 or 850 Interface:

These instruments can be used standalone by reading the digital displays. However, they have special data collection ports that connect a 550 or 850 Universal Interface (see pp. 20-23) to record data and analyze it in PASCO Capstone. Each type of voltage and current reading is automatically identified when the power supply is connected to a 550 or 850 analog port with the special cable (included).

Experiment	DC Power Supply I	DC Power Supply II	DC (Constant Current) Supply	DC Current Amplifier
Photoelectric Effect (page 389)	X			X
Franck-Hertz (page 391)	X	X		X
e/m (page 325)		X	X	

Order Information

Analog 8-Pin DIN Extension
Male-to-Male Adapter UI-5219

DC Power Supply I (Constant Voltage)

SE-6615

- 0 to 6.3 V DC, 1 A maximum
- -4.5 to 0 V DC, 10 mA maximum
- -4.5 to 30 V DC, 10 mA maximum

The 0 to 6.3 V output is independent of the -4.5 to 0 V and -4.5 to 30V outputs, which share an output and are selected by pushing a button.



Specifications:

Independent floating ground reference

Ripple: <1%

Includes:

- Includes cords to connect to the 550 and 850 Interfaces.

Order Information

DC Power Supply I (Constant Voltage) SE-6615

Tunable DC Power Supply (Constant Current)

SE-9622

- 0 to 3.5 A DC, 20 V maximum
- Fixed 6.3 V AC, 1 A maximum



This constant current power supply has a digital readout for the current, which can be tuned from 0 to 3.5 A DC. It also has a 6.3 V AC power supply for heating filaments. A High Current Sensor (PS-2193 or CI-6740) can read the current when using this power supply with interfacing experiments. Both DC and AC outputs are available simultaneously on separate floating output terminals.

Order Information

Tunable DC Power Supply (Constant Current) SE-9622

DC Power Supply II (Constant Voltage)

SE-9644

- 0 to 12 V DC, 1 A maximum
- 0 to 100 V DC, 30 mA maximum
- 0 to 200 V DC, 30 mA maximum

The 0 to 12 V output is independent of the 0 to 100 V and 0 to 200V outputs, which share an output and are selected by pushing a button.



Specifications:

Independent floating ground reference

Ripple: <1%

Includes:

- Includes cords to connect to the 550 and 850 Interfaces.

Order Information

DC Power Supply II (Constant Voltage)..... SE-9644

DC Current Amplifier

SE-6621

- Measures picoamp currents
- Six ranges from 10^{-8} A to 10^{-13} A

DC Current Amplifier designed for Franck-Hertz and Photoelectric Effect experiments.



Specifications:

Maximum Voltage Input: 15 V

Zero Drift: $\leq 0.2\%$ of full range 10^{-13} A after 30 min.

Includes:

- Includes cords to connect to the 550 and 850 Interfaces.

Order Information

DC Current Amplifier SE-6621

Tunable DC Power Supply 6A

SE-9656

- Used in Zeeman Effect experiment
- Can be used in the e/m experiment to power the coils
- Maximum current of 6 A



The Tunable DC Power Supply supplies power to the pen-type mercury lamp and the electromagnet (SE-9655) in the Zeeman Effect Apparatus (SE-9654). The output for the mercury lamp is 1500 V AC and the output for the electromagnet is zero to 6 A with a maximum voltage of 36 V DC.

Specifications:

AC Output: Fixed 1500 V, maximum current 145 mA

DC Output: Constant current adjustable from zero to 6 A

Maximum Voltage: 36 V

Extra Fuse Included: 250 V T5A

Order Information

Tunable DC
Power Supply 6ASE-9656

Wide Range Function Generator

SB-9549A



This function generator is similar to the Basic Function Generator, but it provides a wider frequency range and greater output voltage.

Specifications:

Ranges: 0.2 Hz to 5 MHz in seven ranges, (± 1 count)

Waveforms: sine (distortion $< 1\%$ below 100 kHz); square (2% symmetry, 50 nS max rise and fall time); triangle (98% linearity below 100 kHz, 95% above 100 kHz)

Outputs: 20 Vpp no load, 10 Vpp max into 50 Ω load; continuously variable, 20 dB range with 20 dB step; DC offset: ± 10 V (no load), ± 5 V (50 Ω load); TTL/CMOS-compatible pulse

Sweep: external voltage-controlled oscillator, 0-10 V signal can produce 100:1 frequency change

Power Source: 115/220 VAC, 50/60 Hz

Accessories: BNC to insulated clips

Order Information

Wide Range
Function GeneratorSB-9549A

AC/DC Power Supply

NEW

SE-9584

- 0 to 24 VDC at 0 to 10 A (up to 12 VDC, maximum 6A up to 24 VDC)
- 0 to 24 VAC at up to 6 A
- Digital readouts



The AC/DC Power Supply has been designed specifically for use in teaching science. It can provide both direct current (DC) and alternating current (AC). The power supply can provide both types of electrical power at the same time, and they can be adjusted independently of one another. Separate digital displays are provided for DC and AC voltage and current outputs.

Features:

- **Voltage Ranges:** 0 to 24 V DC and 0 to 24 V AC
- **Maximum DC Current:** 10 A up to 12 V DC, 6A up to 24 V DC
- **Maximum AC Current:** 6A
- Automatic cooling fan
- **Use both DC and AC outputs simultaneously**

Specifications:

DC Output Voltage: 0 to 24 V DC

DC Voltage Accuracy: 1% ± 2 LSD

DC Output Current: 0 to 10 A (for 0 to 12 V range); 6 A maximum (for 12 V to 24 V range)

DC Current Accuracy: 1% ± 2 LSD

DC Meters: Digital LED display (volts/amps)

AC Output Voltage: 0 to 24 V AC

AC Voltage Accuracy: 2% ± 2 LSD

AC Output Current: 0 to 6 A

AC Current Accuracy: 2% ± 2 LSD

AC Meters: Digital LED display (volts/amps)

Overheating Protection: Auto shut-off

Power Source: AC 110-120/220-240 VAC, 50/60 Hz

Dimensions: 30 x 28 x 13.5 cm (12 x 11 x 5.3 in.)

Cooling Fan: Automatically comes on when warm

Fuse: T8AL250V P

Mass: 3.6 kg

Order Information

AC/DC Power SupplySE-9584

DC Power Supplies

Student Power Supply (18 VDC, 3 A)

SE-8828

- ▶ 0-18 VDC at 0-3 A
- ▶ Constant voltage or current
- ▶ Short-circuit protected
- ▶ Current limiting
- ▶ Low noise/ripple



This high-quality, compact power supply provides the DC voltage and current levels necessary for most introductory student labs.

Specifications:

Digital Meters: Voltage and Current; Backlit LCD

Power Source: AC 100, 120, 220, 240 V $\pm 10\%$, 50/60 Hz; Protection – overload and reverse polarity protected

Constant Voltage:

Output: Continuously variable

Line Regulation: $< 0.01\% \pm 3$ mV

Load Regulation: $< 0.01\% \pm 2$ mV

Ripple and Noise: < 0.5 mVrms

Constant Current:

Output: Continuously variable

Line Regulation: $< 0.2\% \pm 3$ mA

Load Regulation: $< 0.2\% \pm 3$ mA

Ripple: < 3 mArms

Dimensions: 9.4 x 4.25 x 6 in (240 x 108 x 154 mm)

Weight: 6.6 lbs (3 kg)

Order Information

Student Power Supply (18VDC, 3A)SE-8828

Triple Output Power Supply

SE-8587

- ▶ 0-30 VDC at 0-3 A
- ▶ Digital Voltage and Current Meters



This power supply offers adjustable voltage output (0-30 V), adjustable current output (0-3 A), and two independent constant voltage outputs (5 V and 12 V) with easy snap terminals. Digital displays of both current and voltage allow students to easily gather data. Features overload and short-circuit protection.

Specifications:

Digital Meters: Voltage and Current; 3 digits; LCD

Power Source: AC 110/220 VAC, 50/60 Hz

Dimensions: 29 x 13 x 15 cm (5.5 kg)

Fixed Output Voltage: 5 V at 0.5 A continuous; 1 A max. 12 V at 0.5 A continuous; 1 A max.

Constant Voltage:

Output: Continuously variable

Line Regulation: $\leq 0.05\% \pm 10$ mV

Load Regulation: $\leq 0.05\% \pm 10$ mV

Ripple and Noise: ≤ 0.5 mVrms

Constant Current:

Output: Continuously variable

Line Regulation: $\leq 0.05\% \pm 10$ mA

Load Regulation: $\leq 0.05\% \pm 10$ mA

Ripple and Noise: ≤ 3 mArms

Order Information

Triple Output Power SupplySE-8587

High Voltage DC Power Supply

SE-9700



This DC power supply provides four independently adjustable DC voltages:

- 0 to 500 V DC, maximum 50 mA
- 0 to 50 V DC, maximum 50 mA
- 0 to 8 V DC, maximum 3 A
- 0 to 12 V DC, maximum 4 A

Applications:

- Use the 500 V DC supply to energize the plates of the Millikan Oil Drop Apparatus.
- Use the 8 V DC supply to power filaments.
- Use the 500 V DC supply to accelerate the electrons in the e/m experiment.
- Use the 12 V DC supply to power Helmholtz coils.

Features:

- Four independently adjustable DC voltages
- Over-current LED indicator
- LED voltage displays
- Switchable voltage input 110V/220V
- Cooling fan

Specifications:

Channel 1 Voltage Range (maximum current):
0 to 500 V DC (50 mA)

Channel 2 Voltage Range (maximum current):
0 to 50 V DC (50 mA)

Channel 3 Voltage Range (maximum current):
0 to 8 V DC (3 A)

Channel 4 Voltage Range (maximum current):
0 to 12 V DC (4 A)

Channel 1 Ripple and Noise: 20 mV rms

Channel 2, 3, 4 Ripple and Noise: 5 mV

Display Accuracy: $\pm$ (1% reading + 2 digits)

Dimensions: 26 x 16 x 34 cm

Mass: 7.8 kg

Includes:

- DC Power Supply
- Power cord
- Extra fuse

Order Information

High Voltage DC Power SupplySE-9700

Kilovolt Power Supply

SE-9586

NEW

- Digital readout
- 0 to 6 kVDC
- 6.3 VAC, 2 A filament source



This Kilovolt Power Supply is used for electron tubes and electrostatics.

The high voltage section is by design “floating” relative to ground. This means that either the black (negative) terminal or the red (positive) terminal may be connected to ground to give a voltage range of 0 to +6 kV, resp. 0 to -6 kV relative to ground.

In addition to the DC kilovolt output, a 6.3 VAC output is provided to power filaments in electron tubes.

The output is well regulated, and the current is limited for safety. The maximum short circuit current is 2 mA. The power supply output shuts off when the maximum current is exceeded and then it automatically resets.

Applications:

- Charge conductive spheres for Coulomb's Law experiment.
- Use the AC output to power heater filaments in electron tubes.

Specifications:

DC Output Voltage: 0 to 6 kV, continuously adjustable

Short Circuit Current: 2 mA (max.)

Ripple and Noise (max.): Less than 1%

Accuracy: 1% + 0.01 kV

AC Output Voltage: 6.3 V

Maximum AC Output Current: 3 A

Dimensions: 28 cm (W) x 30 cm (D) x 13.5 cm (H)

Power Source: 110-120/220-240 VAC

Fuse: F1AL250V

Mass: 4.5 kg

Includes:

- Kilovolt Power Supply
- High Voltage Patch Cords (2)

Order Information

Kilovolt Power SupplySE-9586

Function Generator

Function Generator

PI-8127

- ▶ 0.001 Hz to 150 kHz
- ▶ Programmable frequency sweep
- ▶ 10 V at 1 A
- ▶ Use for circuits and/or driving speakers
- ▶ Use the ramp function to vary the speed of DC motors
- ▶ Frequency resolution of 0.001 Hz over entire range



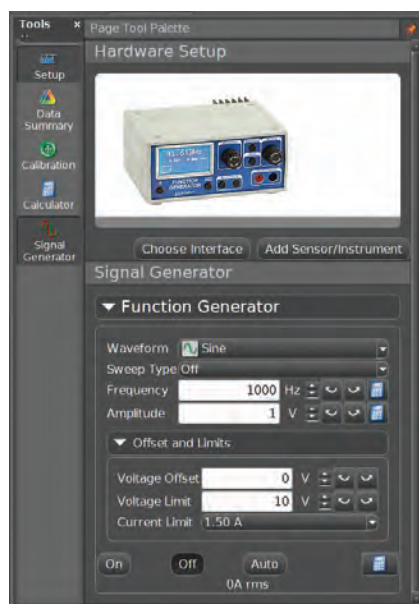
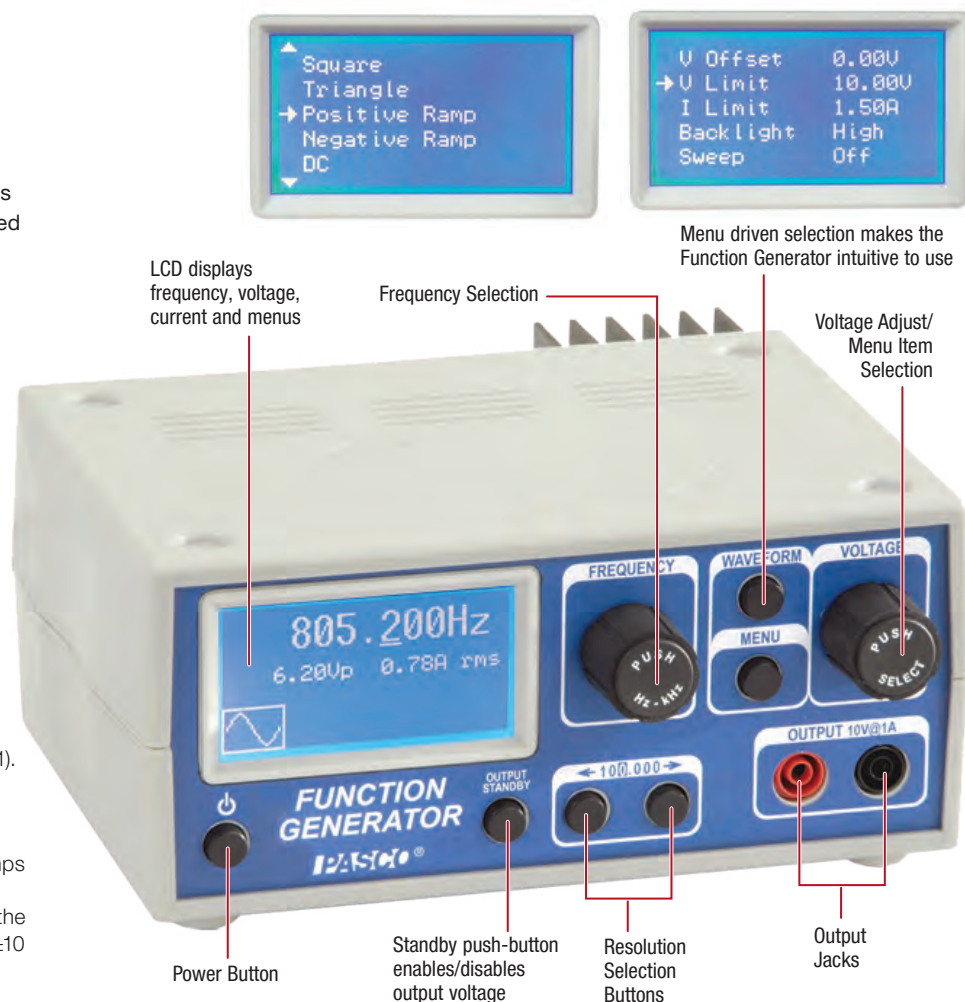
Upgradable Firmware

Download the latest features for your PI-8127: The built-in USB port allows users to access and upgrade firmware whenever the unit is attached to a computer running current versions of PASCO Capstone™ software (pp. 68-71).

Features

The Function Generator outputs sine, square, triangle, positive and negative ramps with a frequency range of 0.001 Hz to 150 kHz in addition to DC. (A replacement for the PI-9587C). Its powerful output, 1 Amp at ± 10 Volts, makes it useful for driving speakers, string vibrators, and circuits.

- ▶ **LCD Readout:** The LCD displays frequency, voltage, current, waveform, and menus. For viewing demonstrations, there is a Large Digits Mode for increased readability of the frequency. The backlight has both low and high levels, which are selectable in the menu. The low backlight is useful for dark rooms.
- ▶ **Frequency/Range Selection:** There are two ranges, 0.001 to 100 Hz and 0.001 to 100 kHz, selected using the range push-button switch (integrated with frequency knob).
- ▶ **Output Standby:** Pushing the standby button disables the output without changing settings.
- ▶ **Output Current/Voltage Maximum:** The maximum current or maximum voltage can be set using the menu. This is useful when the instructor needs to limit the voltage applied to a light bulb.
- ▶ **Offset Voltage:** Any waveform may be offset with a DC voltage ranging from -10 V to +10 V, provided the peak voltage does not exceed 10 V.
- ▶ **Frequency Sweep:** Sweep between any two frequencies at a selectable rate.



Use the Function Generator as a standalone or connect it to a computer via USB cable and control all its functions from PASCO Capstone™. Use it with PASPORT interfaces and sensors.

Specifications:

Input Power: 15 V @ 1.6 A

Voltage Output: ± 10 V @ 1 A

Frequency Range: DC to 100 kHz.
Sine wave retains its form to 150 kHz.

Frequency Resolution: 0.001 Hz over entire range

Offset Voltage: ± 10 V

Waveforms: Sine, Triangle, Square, Positive Ramp, Negative Ramp, DC

External Voltage Input: ± 10 V Maximum

Trigger Output: TTL Compatible;
BNC jack on back of unit

Display: LCD Graphics Monochrome Display, 128 x 64, with two-level backlight

Displays: Frequency, Waveform, Voltage, Current, Offset Voltage.

Amplitude Modulation: Modulate the signal of one function generator using another.

Order Information

Function Generator PI-8127

AC/DC Smart Power Supply

PI-9525

The AC/DC Smart Power Supply is a Bluetooth Low Energy wireless signal generator. It outputs DC as well as sine, square, positive square, and triangle AC signals. The maximum power output is 10 V at 1 amp and the maximum output frequency is 100 kHz.

The AC/DC Smart Power Supply is controlled through PASCO Capstone or SPARKvue software. The ability to control this power supply through Bluetooth makes it possible for users of Chromebooks, Android, and Apple IOS devices to do experiments with wireless sensors that require a power source.

NEW



Shown in use with the Wave Driver (WA-9855)

Applications:

- Power the Wave Driver (WA-9855) to show resonances in a vibrating string
- Power the Wave Driver (WA-9855) to show resonances in a Chladni plate
- Power the Mechanical Oscillator/Driver (ME-8750) to drive the oscillation of a Smart Cart and spring system
- Power a String Vibrator (WA-9857A) to show resonances in a vibrating string
- Use as a power source for DC and AC electronics experiments

Features:

- **Maximum Power:** 10 V @ 1 A
- **Output Functions:** DC, sine, square, triangle
- **Output Frequency Range:** 0.001 Hz to 100 kHz
- **Software controls:** Choose wave form, frequency, amplitude, and on/off in PASCO Capstone or SPARKvue
- Bluetooth or USB data connection
- Built-in output voltage sensor
- Current limit warning
- Programmable using Blockly code in PASCO Capstone or SPARKvue
- Blockly Library contains special functions for a long ramp and stepping through resonant frequencies.

Specifications:

Maximum Power Output: 10 V @ 1 A

Waveforms: DC, sine, square, positive square, triangle

Output Frequency Range: 0.001 Hz to 100 kHz; resolution 0.001 Hz

Power Adapter: 15 V @ 2.67 A

Output Voltage Sensor Range: ± 10 V

Output Voltage Sensor Maximum

Sample Rate: USB: 100 kHz (monitoring); Bluetooth: 20 kHz (continuous)

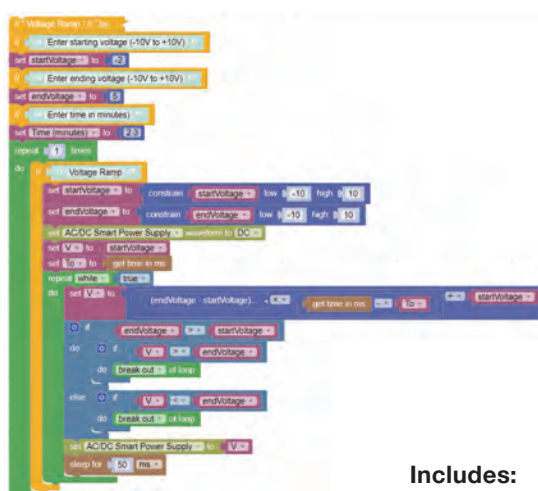
Data Connectivity: USB-C and Bluetooth 5.2

Output jacks: Safety 4 mm banana jacks

Variable Duty Cycle: For positive square wave



The AC/DC Smart Power Supply is controlled in PASCO Capstone or SPARKvue software.



Use Blockly in PASCO Capstone or SPARKvue to program the AC/DC Smart Power Supply. This example shows how to make a very long voltage ramp.

Includes:

- AC/DC Smart Power Supply
- Power Adapter 15 V @ 2.67 A
- USB-C to USB-A cable

Order Information

AC/DC Smart Power SupplyPI-9525

Ripple Tank

Ripple Tank System

WA-9899

- Completely redesigned system
- More affordable
- Integrated strobe/ripple generator simplifies operation
- Foam “beach” design dramatically reduces reflections from walls
- Silent operation

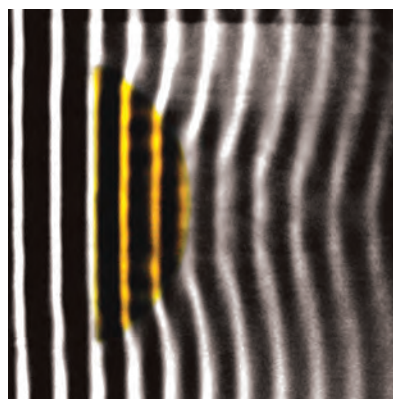
The redesigned Ripple Tank System is easier to use, more reliable, and more affordable. The strobe and rippler are controlled by the same unit, and a new feature makes it possible to introduce a small frequency difference between the strobe and the rippler to make the waves appear to move slowly. A simple switch changes the phase of the two rippers from 0 to 180 degrees.

The rippler uses voice coil actuators for precise and silent operation. The frequency range (1.0 Hz to 50.0 Hz) includes those important low frequencies that make refraction more prominent. The LED digital frequency readout can be seen in low lighting. The rippler has knobs to easily adjust the dipper depth and the amplitude of the dipper stroke.

The new light source is a white LED that remains cool during operation and produces a bright, clear wave pattern. The light can be used as a strobe or in steady mode.

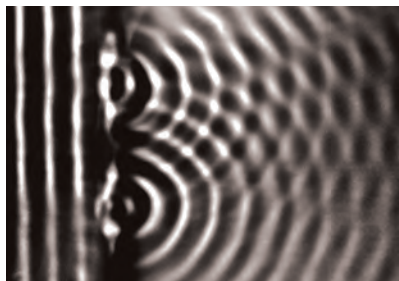
Applications:

- Speed of Wave Propagation
- Superposition of Waves
- Effects of Varying Water Depth
- Reflection, Refraction, and Diffraction



The yellow convex lens focuses the plane water waves. The waves show a pronounced refraction due to the abrupt change in the depth of the water over the plastic lens.

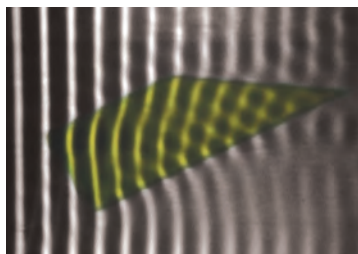




Diffraction Barriers are used to create a double slit to show interference. The barriers can be changed to adjust the slit width and slit separation.



The Doppler effect is clearly demonstrated by moving the dipper. In this picture the movement is downward.



Refraction occurs at the boundaries of this rhomboid shape.

Ripple Tank Specifications (WA-9897):

Viewing Area: 34 cm x 34 cm

Usable Tank Depth: 1 cm

Projection Screen: 35.6 cm x 38.8 cm

Acrylic Mirror: 49.8 cm x 38.8 cm

Light Source Support Rod: 46 cm long

Drain Tube: 30 cm long

Water Resistant Storage Box:

64 cm x 52 cm x 17 cm

Ripple Generator/Light Source Specifications (WA-9896):

Voice Coil Actuator Frequency Range:

1.0 to 50.0 Hz with 0.1 Hz Resolution

Adjustable Delta Frequency between Ripple Generator and Strobe:

±45% frequency setting in steps of 9%

Light Source:

5 W White LED

Light Source Modes:

Strobe or Steady Modes

Digital LED Display:

Frequency/Delta

Phase Switch:

0 or 180 degrees

Power Supply: 1

5 VDC at 1.5 A with On/Off Switch

Rippler Case Dimensions:

10.5 cm x 16.3 cm x 3.9 cm



Order Information

Ripple Tank SystemWA-9899

Required:

90 cm Stainless Steel RodME-8738 p. 204

Large Rod BaseME-8735 p. 204

Replacement:

Ripple Tank Optics Replacement SetWA-9898

Includes:

- Ripple Tank (complete components list at right)
- Ripple Generator/ Light Source
- Water Resistant Storage Box (64 cm x 52 cm x 17 cm)

Ripple Tank Assembly

WA-9897



Includes:

- Tank with Legs
- Projection Mirror and Screen
- Strobe Mounting Rod
- Refractors (convex, concave, rhomboid)
- Curved Reflector
- Diffraction Barriers (2 long, 1 short, 1 mini)
- Plastic Storage Box for components
- Surfactant
- Drainage Tube (30 cm) with Clamp
- 1 L Plastic Beaker
- Pipette
- Clear Plastic Ruler
- Water Resistant Storage Box for Entire System

Order Information

Ripple Tank Assembly WA-9897

Ripple Generator/ Light Source

WA-9896

Includes:

- Ripple Generator/Strobe Driver with Power Adapter
- LED Strobe Assembly
- Plane Wave Generator with Multi-point Dippers
- Point Sources (3 sizes)



Order Information

Ripple Generator & Light Source WA-9896

Ripple Tank Replacement Set

WA-9898

See specifications at left.

Includes:

- Plastic Storage Box for Components
- Dippers
- Refractors
- Pipette
- Curved Reflector
- Foam Beach
- Diffraction Barriers

Order Information

Ripple Tank Optics Replacement Set WA-9898

Ripple Tank Screen and Mirror

WA-9881

- Includes screen and mirror

Order Information

Ripple Tank Screen WA-9881

Standing Waves

String Vibrator

WA-9857A

- Great tool for mechanical wave demonstrations
- Uses magnetic field to drive flexible tongue

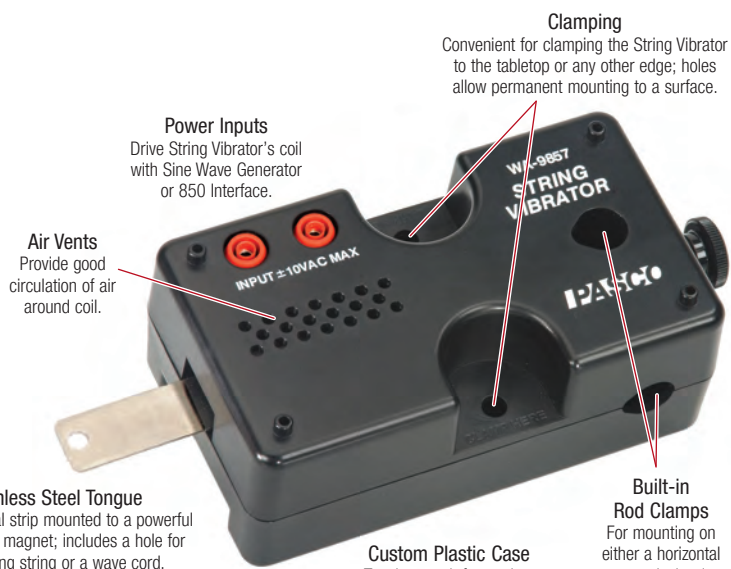
The String Vibrator transforms mechanical wave demonstrations into hands-on activities that every lab group can easily perform. Featuring an elegant design with no motors or speakers, the String Vibrator allows students to study the fundamental characteristics of mechanical waves including wave speed, frequency, wavelength, amplitude, interference, and resonance.

Includes:

- String Vibrator Unit
- 3 Meter Wave Cord (not shown)

Order Information

String Vibrator.....	WA-9857A	
Required:		
Sine Wave Generator	WA-9867	p. 279



Strobe System

ME-6978

- 1 Hz to 500 Hz
- Variable intensity
- Low cost
- External trigger

This unique modular design makes it easy to light any geometry. The Strobe includes the Strobe Control Box and one Strobe Module. Additional Strobe Modules can be purchased separately (see below) for up to a total of four lamp modules per controller, and multiple control boxes can be connected together using the External Trigger. The Strobe Modules have a tilting lamp head on a sturdy base that sits on the table or fastens to a rod stand.

Accuracy: 0.1%

Frequency Range: 1 Hz to 500 Hz

Resolution: 0.1 Hz

Lamp Life: 50,000 hours

Brightness: 230 lumens (peak) per module

Includes:

- Control Box
- Strobe Module

Order Information

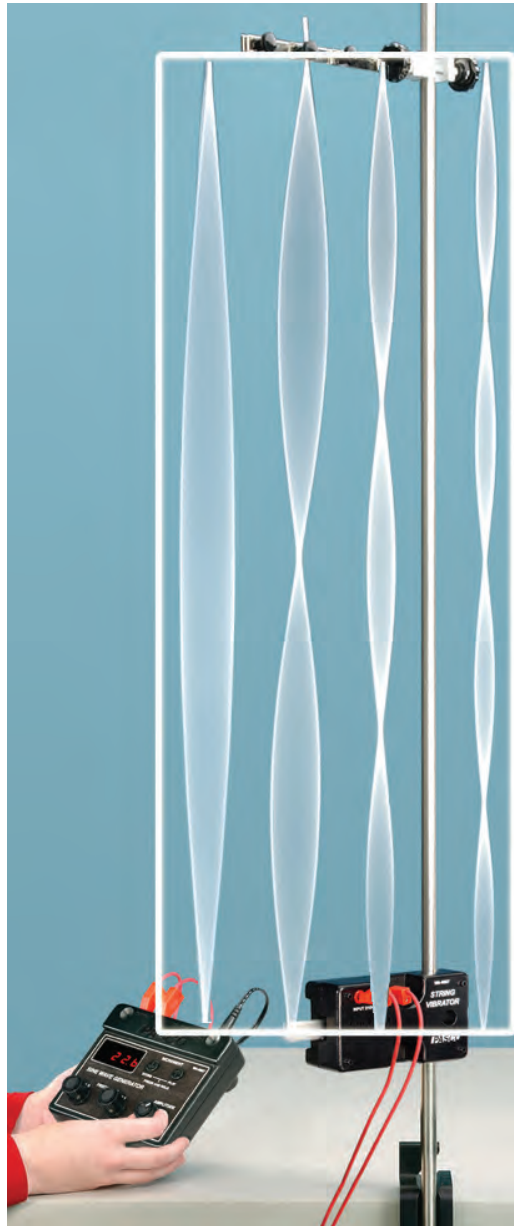
Strobe System	ME-6978	
Shown in use with:		
String Vibrator.....	WA-9857A	
Round Base with Rod (2).....	ME-8270	p. 204
Aluminum Table Clamp (2)	ME-8995	p. 207
Sine Wave Generator	WA-9867	
Multi-Clamp.....	ME-9507	p. 206



Sine Wave Generator

WA-9867

- Sine wave output up to 800 Hz
- Ideal for driving speakers and wave drivers
- Built-in memory for storage of fundamental frequency
- Auto-scan of resonant frequencies



Includes:

- Sine Wave Generator
- Power Supply: 15 VDC 2A



- **Custom Plastic Case:** Stackable plastic case includes angled rubber feet and a rear rod clamp for dynamic mounting options
- **Digital Display:** Frequency is digitally displayed with 0.1 Hz resolution using red LEDs
- **Frequency Adjustment:** Adjust the frequency of the output with either the fine (0.1 Hz) or coarse (1.0 Hz) knobs. The knobs include a "Smart Scan" feature so they change frequency more quickly when continuously turned.
- Smart Scan feature enables knobs to change frequency more quickly when continuously turned.
- **Amplitude Adjustment:** Change the voltage of the sine wave signal.
- **"Learn" Frequency:** The Sine Wave Generator can store a frequency increment, then it will cycle through the selected frequency range by the increment automatically, which is very useful for resonance demonstrations or activities.

Order Information

Sine Wave Generator	WA-9867	
Recommended:		
String Vibrator.....	WA-9857A	p. 278
Wave Driver	WA-9855	p. 280
Open Speaker	WA-9900	p. 282
Economy Resonance Tube	WA-9495	p. 282
Shown in use with:		
2 Meter Patch Cord Set.....	SE-9415A	p. 248

Waves

Wave Driver

WA-9855

- ▶ New improved design
- ▶ Greater amplitude
- ▶ Stronger magnet for stronger force
- ▶ Sturdy construction

This newly redesigned Wave Driver offers improvements in driving force and amplitude as well as a built-in string guide so tiny parts don't get lost. It is ideal for vibrating waves in a string, driving Chladni plates to show the vibration modes, or for demonstrating resonance vibrations.

Use a function generator (sold separately) to power this Wave Driver.

Specifications:

Frequency Response:

0.1 to 5000 Hz

Driving Signal Required:

Requires a function generator with a minimum of 8 V at 0.5 A.



Includes:

- Wave Driver with built-in rod clamp and string holder
- Sample wave string



A coil inside a cylindrical magnet is driven by a sinusoidal signal which comes from the external function generator that is connected to the Wave Driver's banana jacks. The coil is attached to a diaphragm that the actuator rod is connected to.



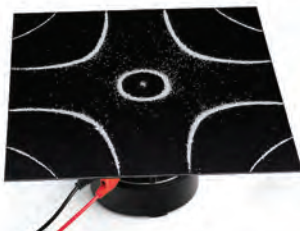
Order Information

Wave Driver	WA-9855	
Required:		
Function Generator		
Banana Plug Cord-Black (5 pack).....	SE-9751	p. 248

Wave Driver Accessories

Chladni Plate

WA-9406



Set this plate on the Wave Driver and sprinkle sand on it to visualize various modes of vibrations. The sand that collects along the nodal lines of the wave patterns paint clear and beautiful pictures of the various modes of vibration.

The Chladni Plate includes a 24 cm x 24 cm square metal plate, 0.8 kg of extra-fine sand, and a sand shaker.



WARNING! This product can expose you to crystalline silica, which is known to the State of California to cause cancer. For more information go to www.P65Warnings.ca.gov.

Order Information

Chladni Plate	WA-9406
---------------------	---------

Chladni Violin Plate

SE-7319

This 40-cm-long metal plate is shaped like a standard violin. Place sand on the plate and excite with a wave driver. Includes a standard banana jack connector for use with the Wave Driver.



Order Information

Chladni Violin Plate	SE-7319
----------------------------	---------

Metal Resonance Strips

WA-9404

These resonance strips demonstrate standing waves, harmonics, and the relationship between length, frequency, and resonance.



Investigate the unique resonant frequencies of the Metal Resonance Strips.

Order Information

Metal Resonance Strips	WA-9404
------------------------------	---------

Resonance Wire Loop

WA-9405

Use this wire loop (29 cm diameter) to introduce Bohr's quantum atom with a classical model.



Order Information

Resonance Wire Loop	WA-9405
---------------------------	---------

Longitudinal Wave Spring

WA-9401

Using the Longitudinal Wave Spring accessory, it is easy to demonstrate and visualize the nodes and antinodes of longitudinal waves. Unstretched length is 13 cm.

Longitudinal waves can be easily demonstrated with the Longitudinal Wave Spring.



Order Information

Longitudinal Wave Spring	WA-9401
--------------------------------	---------

Sonometer

WA-7428

A sonometer is a two-string guitar device that uses hanging weights to create tension in the strings. The two strings have different densities. Students can vary the lengths of the strings using the included bridges and pick (included) or finger to pluck the strings. Sonometers are used to study standing waves in strings, the speed of sound waves in steel, and musical instruments.

Specifications:

- Working Length of Sounding Board:** 50 cm
- Strings:** Steel guitar strings with diameters 0.014-inch and 0.018-inch (4 of each type)
- Tuning Pegs:** For fine adjustments of the string tension
- Built-in Rulers:** Rulers on both sides measuring the string length at the indicator on the bridge
- Tensioning Lever:** 5-to-1 lever to provide tension in the string with built-in bubble level
- Maximum Hanging Mass per String:** 3 kg
- PASCO Guitar Pick:** Yellow Nylon 0.73 mm thick



Features:

- ▶ Tuning pegs for fine adjustment of string tension
- ▶ 5-to-1 tensioning lever allows the tension to be five times the hanging weight
- ▶ Rulers on both sides to measure the string length to the indicator on the bridge
- ▶ Sounding board for resonating the sound of the vibrating strings
- ▶ Stainless steel string guides for durability
- ▶ Tuning Forks
- ▶ Sound Sensor



Includes:

- Sonometer
- Sliding Bridge (2)
- PASCO Guitar Pick (2)
- 0.014 in. steel string (4)
- 0.018 in. steel string (4)

Order Information		
Sonometer.....	WA-7428	
Required:		
Sonometer Strings (set of 8)	WA-7429	
Large Slotted Mass Set.....	ME-7566	p. 215
Short Slotted Mass Set (2 kg set)	ME-7589	p. 215
Recommended		
Wireless Sound Sensor	PS-3227	p. 62
Tuning Fork Set.....	SE-7342	p. 287
OR		
Tuning Fork Technical Set	SE-7728	p. 287

Sonometer Strings

WA-7429

This replacement set of strings for the Sonometer (WA-7428) contains four each of the following strings:

- 0.014 in. steel string
- 0.018 in. steel string

Order Information

Sonometer Strings.....WA-7429

Resonance

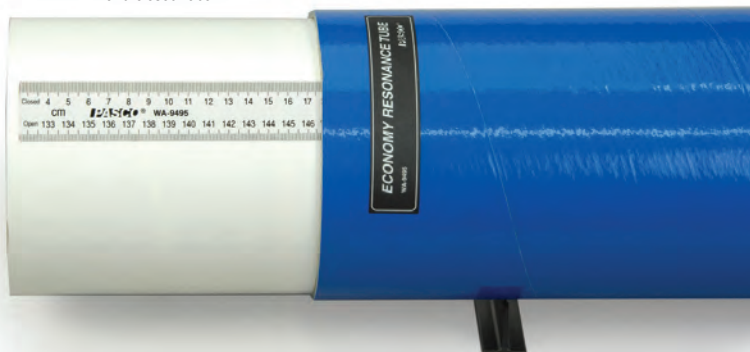
Demonstrate Acoustic Resonance

Economy Resonance Tube

WA-9495



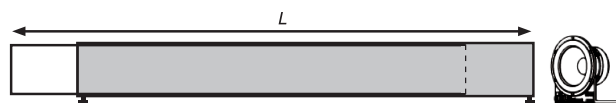
Metric Scale
Directly measures length of air column for open and closed tube.



Students will have no difficulty hearing resonant frequencies from this tube. Two nested cardboard tubes allow the length of the air column to be easily varied. And the inner tube contains a removable end-cap to change from a "closed" to an "open" tube. The length of the resonating column can be read directly off the metric scale for both open and closed operation.



The removable end-cap on the inner tube allows the air column to act as either an "open" or a "closed" tube.



Shown in use with the Open Speaker and the Sine Wave Generator.

Open Speaker WA-9900

Features a high-quality, 13.3 cm woofer mounted on a sturdy base with standard banana jack inputs. The Open Speaker is not enclosed inside a case, making it perfect for resonance experiments.

Frequency Response: 80 - 8000 Hz

Impedance: 8 Ω

Input Power: 60 W (max)



Order Information

Open Speaker WA-9900

Includes:

- Outer Tube Length 1.3 m; Diameter 0.15 m
- Inner Tube (includes measuring tape and removable end-cap)
- Tube Stands (2)

Order Information

Economy Resonance TubeWA-9495

Shown in use with:

Open SpeakerWA-9900

Sine Wave GeneratorWA-9867

2 Meter Patch Cord Set.....SE-9415A

p. 279

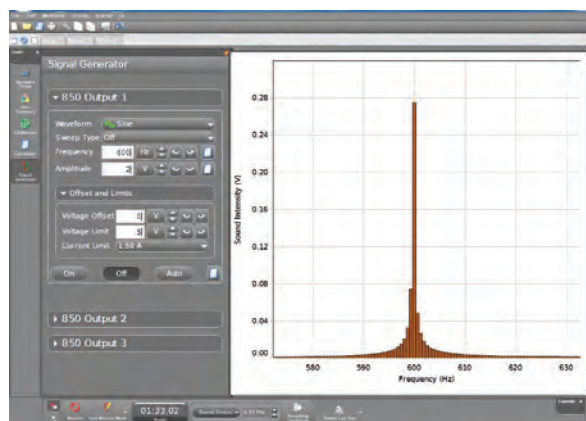
p. 248

Resonance Air Column with Speaker

WA-9594

- ▶ Very loud resonance
- ▶ Tough polycarbonate tube
- ▶ Use with speaker or tuning fork

The Resonance Air Column (WA-9606) emits a very loud sound when the plunger is moved to a node position. It also works as well as a water column but without the mess. The secret is in the long molded piston head, which is very efficient in reflecting the sound waves. The plunger handle is made of flexible acetyl so it will not break.



PASCO Capstone controls the sine wave output of the 550 Universal Interface to drive the speaker. The FFT display of the Sound Sensor data shows the tube's resonant response.



The Resonance Air Column has a polycarbonate tube, so it will not break or chip like inferior acrylic. It includes eight plastic snap-on rings that can be slid along the tube to mark the nodes. A meter stick is used to read the positions of the rings.

The Sound Sensor (UI-5101) has a microphone on a 1.4 m long wire, so it can be used to find the nodes inside the Resonance Air Column.



The Resonance Air Column can be used as a closed or open tube. In the closed mode, tuning forks or speakers are suitable for sound sources. In the open mode, a speaker with a signal generator is required to vary the frequency until the tube sounds a resonance.



WA-9594 includes:

- Resonance Air Column (WA-9606)
- Mini Speaker (WA-9605)

WA-9606 includes:

- Tube and plunger
- Node markers (8)
- Detachable stands (2)

Mini Speaker WA-9605

The Mini Speaker (WA-9605) is specially made to work with the Resonance Air Column. It can be powered with the Function Generator (PI-8127), an 850 Universal Interface (UI-5000), or a 550 Universal Interface (UI-5001). It is also useful as a standalone speaker for doing interference demonstrations. Two Mini Speakers acting as point sources can output the same frequency and the spatial interference pattern can be explored.

Voltage: 10 V

Power: 2 W

Impedance: 8 Ω

Protection Resistor: 15 Ω , 2 W



Order Information

Mini Speaker WA-9605



Material: Polycarbonate

Length: 4.0 ft (1.2 m)

Diameter: 1.5" O.D. (3.8 cm)

Wall Thickness: 1/16" (1.6 mm)

Plunger Length: 4.2 ft (1.3 m)

Plunger Handle: Acetyl

Order Information

Resonance Air Column with Speaker WA-9594

Resonance Air Column WA-9606

Shown in use with:

550 Universal Interface UI-5001 p. 23

Sound Sensor with Microphone UI-5101 p. 28

Tuning Fork Set SE-7342 p. 287

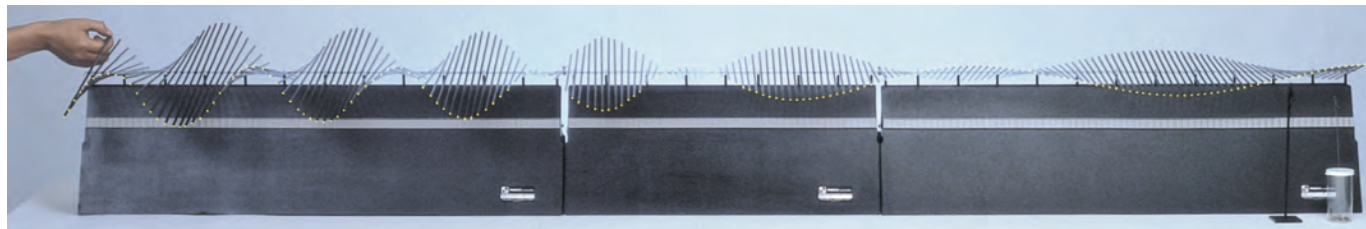
2 Meter Patch Cord Set SE-9415A p. 248

Transverse Waves

Complete Wave Motion Demonstrator

SE-9600

- Produces slow-moving, high-amplitude transverse waves
- Demonstrates all basic wave phenomena



The complete Wave Motion Demonstrator in three sections: The high-amplitude, slow-moving waves provide a fascinating introduction to basic wave phenomena.

The PASCO Complete Wave Motion Demonstrator allows mechanical waves to be created to demonstrate the behavior and properties common to many types of waves.

How It Works:

A series of steel rods is attached at their centers to a torsion wire. When a rod is displaced and released, a wave propagates along the rod. Velocity depends on the torsion constant of the wire and the moment of inertia of the rods.

Features:

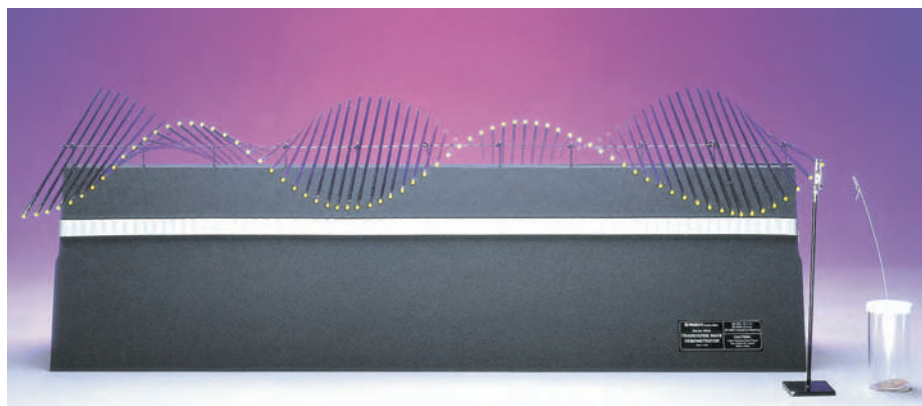
- **2.3 Meters Long:** Plenty of room to watch the wave develop and interact.
- **Three Wave Sections:** Each section has rods of different lengths, allowing reflection and transmission demonstrations.
 - Section 1 is 92 cm long with 46 cm rods.
 - Section 2 is 92 cm long with 23 cm rods. The resulting wave velocity is three times as fast.
 - Section 3 is 46 cm long with rods that vary exponentially from 46 cm to 23 cm. This section acts as an impedance-matching unit.
- **Yellow Rod Tips:** For easy viewing and to highlight the wave motion.
- **Folds:** For compact storage.
- **Easy Setup**

Order Information

Complete Wave Motion Demonstrator SE-9600

Single Section Wave Motion Demonstrator

SE-9601



A-frame design collapses for easy storage.

Includes:

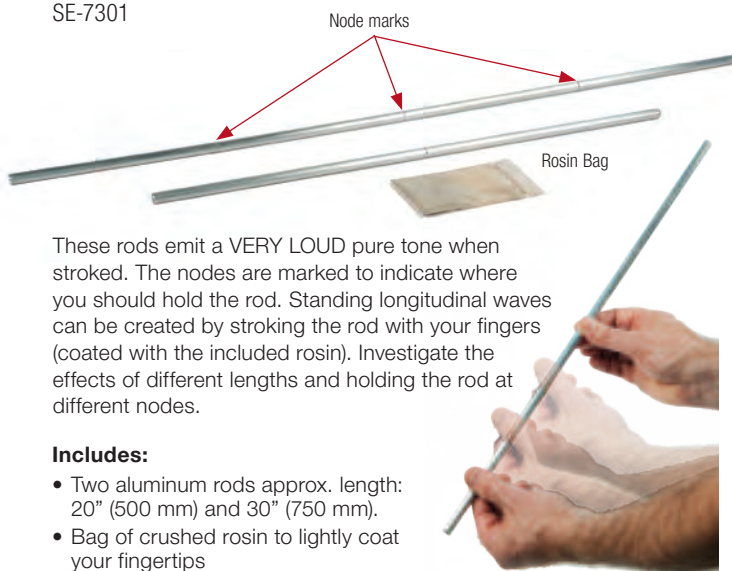
- Section with 46 cm long rods
- Total length of section: 92 cm
- Clamp for rigid termination
- Dash pot for liquid damping

Order Information

Single Section Wave Motion Demonstrator SE-9601

Singing Rods

SE-7301



These rods emit a VERY LOUD pure tone when stroked. The nodes are marked to indicate where you should hold the rod. Standing longitudinal waves can be created by stroking the rod with your fingers (coated with the included rosin). Investigate the effects of different lengths and holding the rod at different nodes.

Includes:

- Two aluminum rods approx. length: 20" (500 mm) and 30" (750 mm).
- Bag of crushed rosin to lightly coat your fingertips

Order Information

Singing RodsSE-7301
 Replacement Supplies:
 Rosin BagSE-6659

Boomwhackers Boomophone

SE-7430



These eight tubes of different lengths provide a fun way to demonstrate standing waves in open and closed-end pipes. The tubes are color-coded for each note in the C-major scale. Insert one end of a tube into a cap to show how the resonant frequency changes when it becomes a closed-end pipe.

You can play the pipes as a xylophone by mounting them in the included tube holder and striking them with the two included mallets. The tube holder also provides convenient storage in between experiments.

Order Information

Boomwhackers Boomophone..... SE-7430

Snakey

SE-7331

This extra-long metal spring is ideal for studying mechanical waves.

The Snakey has an unstretched length of 2 meters. Pull the convenient end loops more than 10 meters apart to demonstrate transverse, longitudinal, and standing waves.



*Easily create
clear standing
wave patterns.*

Order Information

Snakey SE-7331

Bell Jar

SE-7725

This thick glass bell jar with base plate includes an electric bell on a rubber mount to demonstrate that sound does not propagate in a vacuum. Remove the air from the jar and the sound from the bell gradually fades.

Vacuum Pressure:

≤ -0.06 MPa

Voltage:

3 V DC

Jar: 6.5" dia. x 9.75" tall
 (inside: dia. 6.25" x 8" tall)

Base: 8" dia. x 1.5" high



Includes:

- Glass bell jar
- Vacuum base plate
- Gasket
- Hose
- Battery-operated electric bell (removable)



Order Information

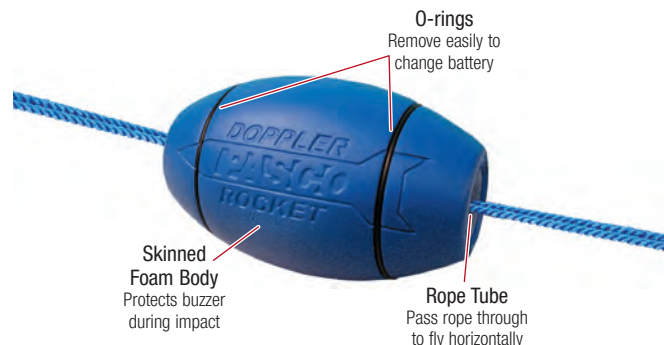
Bell Jar SE-7725
 Required: 2 AA batteries, Vacuum Pump

Wave Media

Doppler Rocket

WA-9826

- Experience the frequency shift of sound waves
- Easily generate high velocity motion
- Rugged construction



Fly Horizontally

A set of two ropes can be passed through the center of the unit. This allows students to use the included handles to propel the Doppler Rocket across the room at high velocities. The unit is guided by the ropes. Students hear the change in pitch as the Doppler Rocket flies past them.



The Doppler Rocket combines the elements of a toy with an audio Doppler shift to create an educational experience students won't forget. The Doppler Rocket emits a true, sinusoidal sound waveform at a constant frequency of approximately 620 Hz. The circuit and speaker are housed in skinned foam that protects the unit during normal impacts. The circuit is powered by a 9 V battery. As the Doppler Rocket passes the students, they hear a noticeable shift in frequency. Velocities of 10 m/s can be easily achieved, resulting in a 20 Hz shift in frequency.



Includes:

- Doppler Rocket
- Rope (30 m)
- Handles (4)
- Handle Cushions (4)
- Battery (9 V)

Order Information

Doppler Rocket.....WA-9826

Sound Pipe

SE-7724



When a student spins this pipe, the pipe produces an audible tone similar to that produced by blowing across the mouth of a bottle. As the pipe is spun faster, the resonant frequency increases. Five different frequencies can be achieved. (One pipe included. Color may vary.)



Sound Pipe SE-7724

Double-Length Slinky

SE-8760

The Slinky is an excellent tool for demonstrating transverse and longitudinal wave phenomena. This Double-Length Slinky is twice as long as a traditional Slinky, allowing students to create well-defined wave pulses and standing wave patterns. The tension in the Slinky is very low, causing wave pulses to travel slowly throughout its length.



Order Information

Double-Length Slinky..... SE-8760

Elastic Wave Cord

SE-9409

This highly visible elastic cord can be used to set up standing transverse waves, or plucked to demonstrate wave propagation. Approximately 3 mm diameter and 90 meters in length.

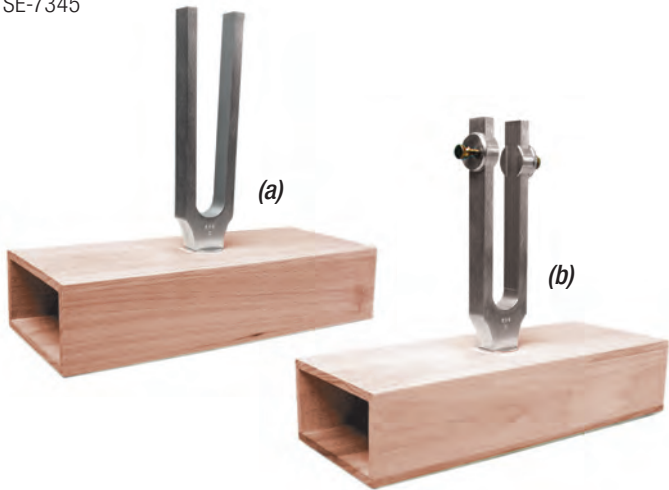


Order Information

Elastic Wave Cord SE-9409

Sympathetic Resonance Box Set

SE-7345



Resonance boxes are great instruments for amplifying sound from a tuning fork. These boxes are constructed from hardwood and feature an A4 tuning fork mounted directly to the box. Use Capstone software and a sound sensor (UI-5101) to measure the sound waves and beat frequencies created by these resonance boxes.

Includes:

- Hardwood resonance box with a 256 Hz A4 tuning fork
- Hardwood resonance box with an adjustable tuning fork

Order Information	
Sympathetic Resonance Box Set.....	SE-7345
Recommended:	
Sound Sensor	UI-5101
850 Universal Interface.....	UI-5000
PASCO Capstone Software.....	pp. 8-11

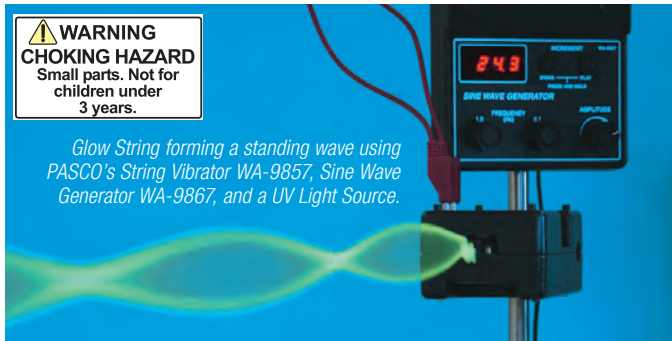
Glow String (2 pack)

SE-8690

This stretchy “string” glows in the dark after being exposed to light. Use it to demonstrate wave motion, including resonance and standing wave patterns. Two rolls are included, totaling over 15 meters of string.



String color may vary.



WARNING
CHOKING HAZARD
Small parts. Not for children under 3 years.

Glow String forming a standing wave using PASCO's String Vibrator WA-9857, Sine Wave Generator WA-9867, and a UV Light Source.

Order Information	
Glow String (2 pack)	SE-8690

Tuning Fork Set

SE-7342



The tuning fork has long been the tool of choice to help students understand the relationship between wave frequency and pitch. These high-quality aluminum tuning forks are both rugged and economical. The set includes eight forks representing a full octave of frequencies, a soft protective case, and a rubber mallet.

Note	Frequency
C	256 Hz
D	288 Hz
E	230 Hz
F	341.3 Hz
G	384 Hz
A	426.7 Hz
B	480 Hz
C	512 Hz

Order Information	
Tuning Fork Set.....	SE-7342

Tuning Fork Technical Set

SE-7728

This tuning fork set consists of six aluminum tuning forks: 125, 250, 500, 1000, 2000, and 4000 Hz. The frequencies are stamped on the forks.



Order Information	
Tuning Fork Technical Set	SE-7728

Basic Optics System

Basic Optics System

OS-8515D

- Geometric and ray optics
- Concave and convex lenses
- Concave/convex mirror

PASCO's Basic Optics System is easy-to-use, affordable, and ruggedly designed. Large, 50 mm diameter optics components are mounted in protective holders that snap directly onto the aluminum track, allowing students to easily adjust components by snapping or sliding them along the track.

Image and object distances for both lenses and mirrors can be measured quickly and accurately with the built-in metric tape. The Light Source doubles as a tabletop ray box for studies in reflection, refraction, color addition, and Snell's Law. All of the components, with the exception of the track, fit in the included storage box.

Viewing Screen

White plastic screen snaps into the optics bench and the position of the screen can be read directly on the bench scale.

Adjustable Lens Holder

Use your own lenses (from 19 mm to 75 mm in diameter) or choose from our lens sets.

Four 50 mm Diameter Lenses

+100, +200, +250, -150 mm lenses are mounted in protective holders.

Concave/Convex Mirror

50 mm diameter plastic mirror with reflective surface on both sides; includes "half-screen" upon which the image is focused.

Ray Optics Kit

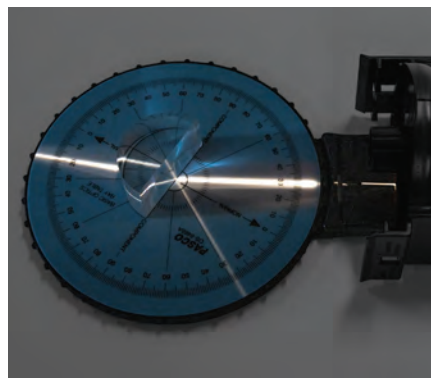
Includes concave/convex lenses, concave/convex/plane mirrors, acrylic rhomboid for prism spreading of white light and refraction experiments, and hollow lens for teaching the Lensmaker's Equation. Also includes storage tray that can be used as a water tank for the hollow lens.

Optics Bench (1.2 m)

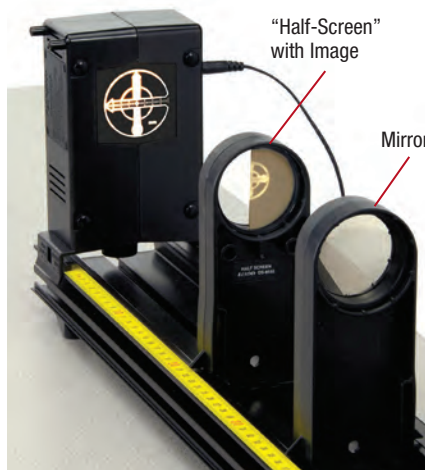
The lenses, mirrors, light source, and screen snap into this rugged aluminum extrusion. The metric tape makes position measurements easy.

Ray Table

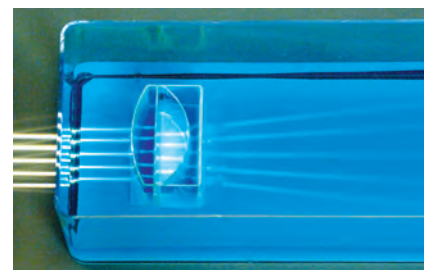
Two-piece construction allows the table to be rotated to study Snell's Law or the Law of Reflection. Includes D-shaped acrylic lens.



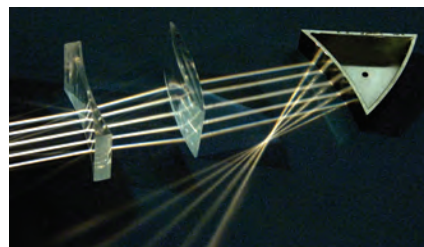
Ray Table in use showing both the reflected and refracted rays



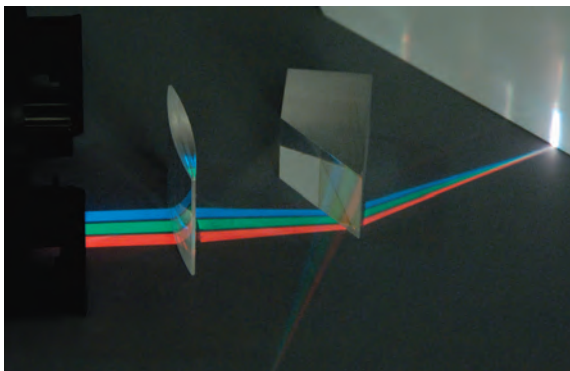
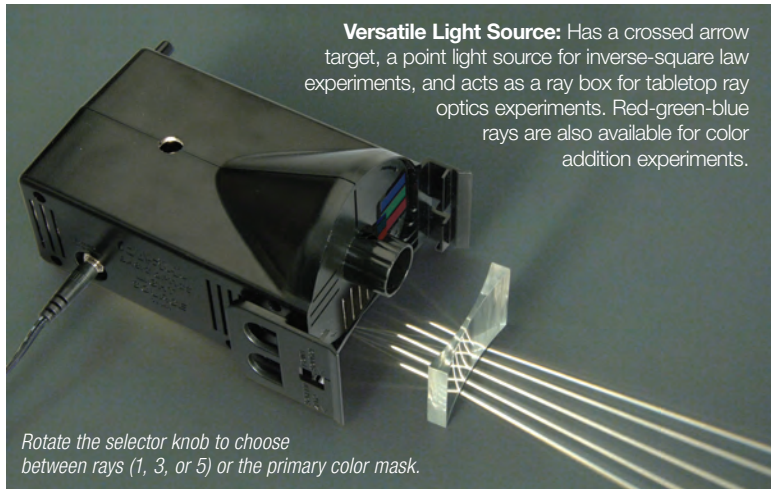
Light Source: Has a well-lit crossed arrow target with metric scale for focusing images through lenses or for use with the concave mirror.



The storage tray is used to create a "hollow" air-filled convex lens. Note that the rays diverge.



Components from the Ray Optics Kit showing refraction and reflection



The primary color mask supports experiments in color addition using components from the Ray Optics Kit.



Perform These Experiments:

- | | | |
|-----------------------------|--|------------------------------|
| ▶ Color Addition | ▶ Lensmaker's Equation | ▶ Virtual Images |
| ▶ Prism | ▶ Apparent Depth | ▶ Telescopes and Microscopes |
| ▶ Reflection | ▶ Reversibility | ▶ Index of Refraction |
| ▶ Snell's Law | ▶ Dispersion | ▶ Shadows |
| ▶ Total Internal Reflection | ▶ Focal Length and Magnification of a Thin Lens | ▶ Brewster's Angle |
| ▶ Convex and Concave Lenses | ▶ Focal Length and Magnification of a Concave Mirror | |
| ▶ Hollow Lens | | |

Basic Optics System Storage Box

All components (except the track) fit in the custom foam box. There are additional slots for accessory lenses (see pp. 292-293).



Includes:

- 1.2 m Optics Track: OS-8508
- Basic Optics Light Source: OS-8470
- Accessory Lens Set: OS-8519
- Adjustable Lens Holder: OS-8474
- Ray Optics Kit: OS-8516A
- Polarizer
- Basic Optics Viewing Screen: OS-8460
- Basic Optics Ray Table: OS-8465
- Basic Optics Geometric Lens Set: OS-8456
- Storage Box

Order Information

Basic Optics System OS-8515D

Basic Optics Components and Accessories

Dynamics Track Optics

p. 290



System Components

p. 291



Accessories & Lens Sets

pp. 292-294



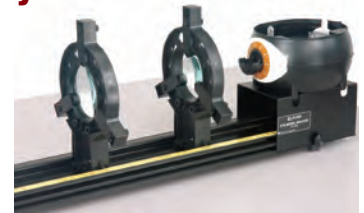
Color Mixer

p. 295



Human Eye Model

pp. 296-297



Diffraction

pp. 298-303



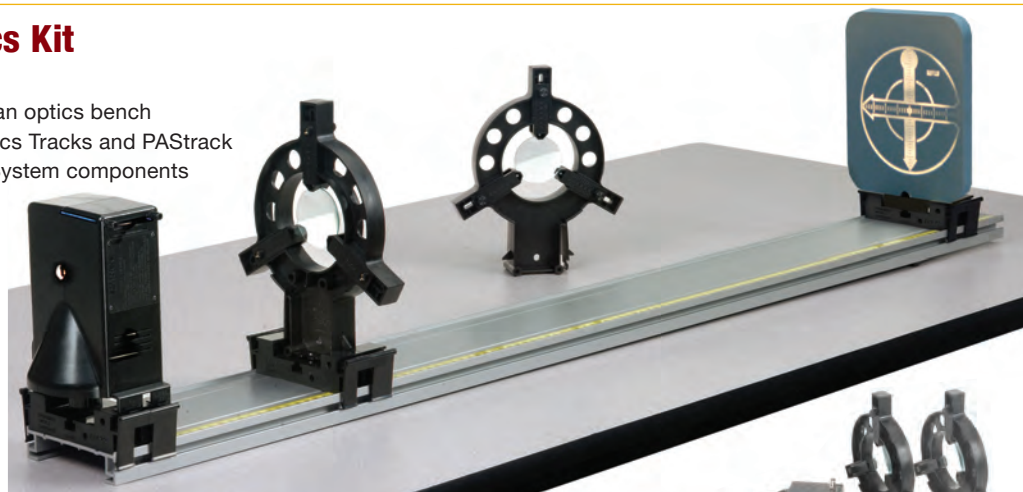
Dynamics Track Optics

Dynamics Track Optics Kit

OS-8471A

- Turns your dynamics track into an optics bench
- Use with 1.2 m or 2.2 m Dynamics Tracks and PASTrack
- Expandable with Basic Optics System components

The PASCO Dynamics Track Optics Kit includes specially designed slides (carriages) that snap on the dynamics track. PASCO Basic Optics components attach directly to the carriage for positioning anywhere on the track. Choose from a wide range of optics components to expand your system.



Includes:

- Basic Optics Light Source
- Two Adjustable Lens/Mirror Holders +100 mm, +200 mm, and -150 mm Focal Length Lenses
- Viewing Screen
- Three Optics Carriages



Order Information

Dynamics Track Optics Kit.....OS-8471A
Required:
1.2 m Aluminum Dynamics Track.....ME-9493
OR
2.2 m Aluminum Dynamics Track.....ME-9779
OR
PASTrack.....ME-6960



Typical Experiments

- Focal Length and Magnification of a Thin Lens
- Telescope
- Microscope
- Shadows
- Virtual Images



To see the experiments, type the product number into the search box at www.pasco.com and download the manual.

Beginning Optics System

OS-8459

This system is perfect for finding the focal length of a lens. This is a great starter system for studying optics, and it can be expanded using the components of the Basic Optics System.



Perform These Experiments:

- Focal Length and Magnification of a Thin Lens
- Telescope
- Microscope
- Shadows
- Virtual Images

Includes:

- Basic Optics Light Source (OS-8470)
- Adjustable Lens Holder (OS-8474) (2)
- Geometric Lens Set (OS-8466A)
- Basic Optics Viewing Screen (OS-8460)
- 1.2 m Optics Track (OS-8508)

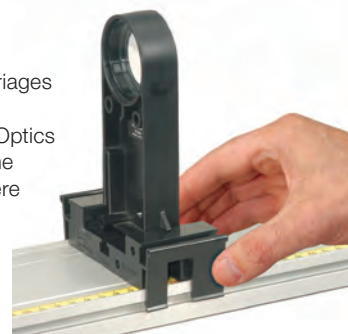
Order Information

Beginning Optics System OS-8459

Dynamics Track Optics Carriages (set of 4)

OS-8472A

The Dynamics Track Optics Carriages are designed to snap onto the PASCO Dynamics Track. Basic Optics components attach directly to the carriages for positioning anywhere on the track.



Includes:

- Carriages (4)

Order Information

Dynamics Track Optics Carriages (set of 4) OS-8472A

Basic Optics Light Source

OS-8470

- One, three, or five parallel rays
- Three primary colors source
- Crossed arrow object and point source

The Basic Optics Light Source is an excellent source for a variety of optics experiments. A single 10-watt quartz-halogen bulb provides bright, easy-to-see illumination without a lot of heat. By turning the box to a different side, it becomes a:

- Crossed Arrow Object with Metric Scale: ideal for showing images, focal point, and magnification.
- Bright Point Source: The very small filament of the halogen bulb provides an excellent point source for experimenting with shadows or the Inverse Square Law.
- Three Primary Colors Source: The red, green, and blue filters provide three rays of light that are easily combined with a lens for color mixing.
- One, Three or Five Ray Sources: Just rotate the knob in front of the light source to vary the number of rays produced.



Rotate the selector knob to choose between rays (1, 3, or 5) or the primary color mask.

The Basic Optics Light Source provides a point source and an extremely bright crossed arrow target. Use free-standing or easily clip directly to Basic Optics Track.



Includes:

- Universal AC Adapter
- Spare Bulb (stored under access cover)

Order Information

Basic Optics Light Source OS-8470

Ray Optics Kit

OS-8516A

The Ray Optics Kit is a basic set of optic components for ray and color experiments.

Includes:

- Double-Convex Lens
- Double-Concave Lens
- Rhomboid
- Eye-Dropper
- Triangular mirror accessory with concave, convex, and plane reflective surfaces
- Hollow lens to fill with a liquid or use as an air lens.



Order Information

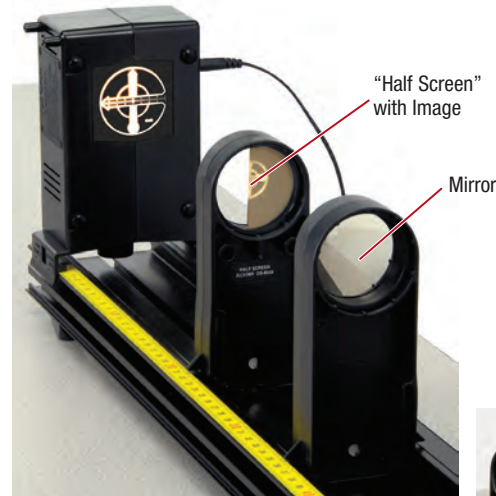
Ray Optics Kit OS-8516A

Concave/Convex Mirror

OS-8457

- 50 mm diameter
- ± 100 mm focal length
- Plastic mirror

This double-sided convex/concave plastic mirror is mounted in a lens holder for easy placement on the Basic Optics Track. This accessory also includes a "half screen" that allows light to pass through on one side, and an opaque screen on the other half to focus the real image formed by the concave mirror.



Includes:

- Concave/Convex Mirror
- Half Screen

Order Information

Concave/Convex Mirror OS-8457

Basic Optics Ray Table

OS-8465A

- Angle of reflection
- Snell's Law
- Total internal reflection



The Ray Table provides an excellent viewing surface for ray optics. The square tab helps align the Basic Optics Light Source. The table can be rotated about its axis to quickly change the incident angle of the ray. The resulting angles of reflection and refraction are easily measured directly off the polar grid printed on the table.

The included acrylic cylindrical D lens simplifies the experiment by having the rays bend at only one surface. Investigate Snell's Law for both cases of rays either entering or leaving the acrylic.

In addition, there is a slot for an optional polarizer (such as found in the Polarizer Set OS-8473 or the Basic Optics System OS8515D). This allows the students to find Brewster's Angle for the acrylic D lens.

Includes:

- Table
- D-shaped Lens

Order Information

Basic Optics Ray Table OS-8465A

Basic Optics Accessories

Aperture Accessories

OS-8524

Aperture Disk:

Simulate the compound lens system of a camera using the Aperture Disk. Simply snap the disk onto one face of a lens. The disk offers six different f-number settings for controlling the amount of light that reaches the viewing screen.

The *f*-number is designated as $f / \#$, where $\#$ equals the focal length of the lens (f) divided by the diameter of the aperture (D). Example uses a +100 mm lens.

<i>f</i> -Number	Aperture Diameter (mm)
$f / 4$	25.0
$f / 5.6$	17.7
$f / 8$	12.5
$f / 11$	8.8
$f / 16$	6.3
$f / 22$	4.4



The Peripheral Mask passes light through the center only.



Spherical Aberration Attachments:

Do the center and outside parts of a lens focus light differently? With the Spherical Aberration Attachments, students will be surprised by the answer. Simply snap the attachments onto a lens from the Basic Optics System and compare the image distance (d_i) for each attachment.



Peripheral Mask shown mounted on +250 mm lens



The Center Mask passes light through an outside ring.

Includes:

- Aperture Disk and Holder
- Spherical Aberration Attachments

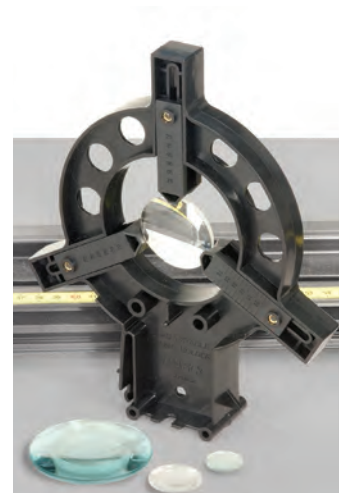
Order Information

Aperture Accessories OS-8524

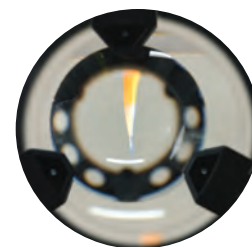
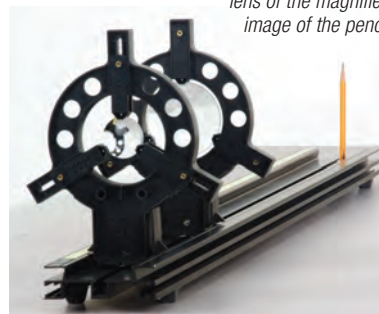
Adjustable Lens Holder

OS-8474

The Adjustable Lens Holder for the Basic Optics System is designed for use with lenses and mirrors with diameters between 19 mm and 75 mm. Simply place the lens or mirror in the holder and adjust the three arms to hold it. A set screw in each adjustable arm ensures that the mirror or lens will remain in place. The holder snaps into the Basic Optics Track and is designed to position all mirrors and lenses at the same height as the rest of the Basic Optics System components.



Actual view through the lens of the magnified image of the pencil



Build a telescope or microscope; shown with 1.2 m Basic Optics Track OS-8508.

Includes:

- Adjustable Lens Holder (lenses not included)

Order Information

Adjustable Lens Holder OS-8474

Lens Holder Set

OS-8522

These holders for the Basic Optics System are an excellent way to permanently mount 50 mm diameter lenses.

Just push in the two retaining rings to hold the lens in place.



Order Information

Lens Holder Set OS-8522

50 mm Diameter Lens Assortment

SE-7581

This set of 6 lenses is made of polished glass with ground edges, and comes in a wooden storage box.

Focal Length (mm)	Description	Focal Length (mm)	Description
+1000	double convex	-1000	double concave
+300	double convex	-200	double concave
+150	double convex	-150	double concave

Order Information

50 mm Diameter Lens Assortment..... SE-7581

Geometric Lens Set

OS-8466A



This is a set of three unmounted 50 mm diameter glass lenses with focal lengths of +100 mm, +200 mm, and -150 mm. These are the same lenses included in the Dynamics Track Optics Kit (OS-8471A) and the Beginning Optics System (OS-8459). They can be mounted in the Adjustable Lens Holder (OS-8474).

Order Information

Geometric Lens Set OS-8466A

Lens Sets

Basic Optics Geometric Lens Set (set of 2)

(+200, +100 mm) OS-8456

Accessory Lens Set (set of 2)

(+250, -150 mm) OS-8519



Each lens is mounted in a lens holder for protection and easy storage. The lens holder clips directly to the Basic Optics Track.

Order Information

Basic Optics Geometric Lens Set..... OS-8456

Accessory Lens Set OS-8519

Ground Glass Lenses (set of 6)

SE-9013



These precision ground glass lenses provide a useful range of focal lengths. Each lens has a 50 mm diameter – small enough for easy mounting, yet large enough for effective viewing. The set of six comes in a convenient storage box.

Focal Length	Description	Focal Length	Description
500 mm	concave convex	-150 mm	double concave
300 mm	plano convex	-300 mm	plano concave
150 mm	double convex	-500 mm	convex concave

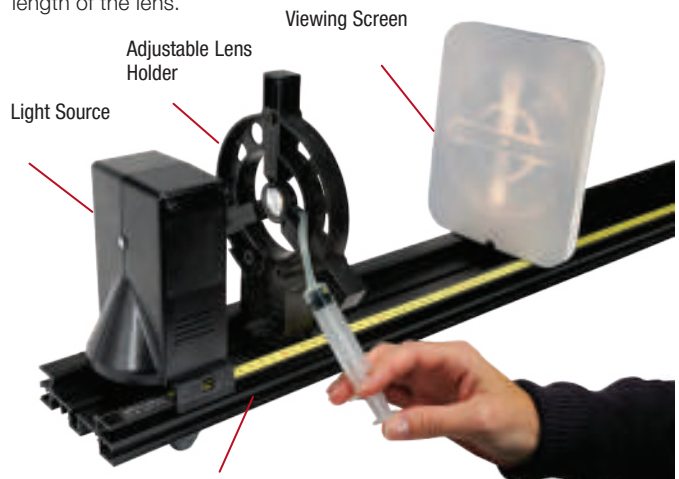
Order Information

Ground Glass Lenses (set of 6)..... SE-9013

Adjustable Focal Length Lens

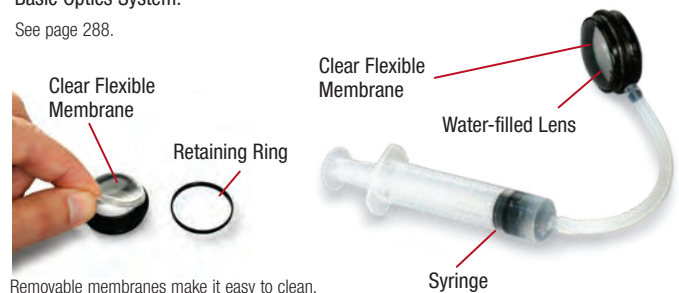
OS-8494

Using the syringe to adjust the amount of water in the lens changes the curvature of the clear flexible membranes and, therefore, the focal length of the lens.



Use the Adjustable Focal Length Lens with your Basic Optics System.

See page 288.



Removable membranes make it easy to clean.

Includes:

- 10 mL Syringe
- 1 ft. Silicon Tubing
- Lenses (2)

Order Information

Adjustable Focal Length Lens..... OS-8494

Shown in use with:

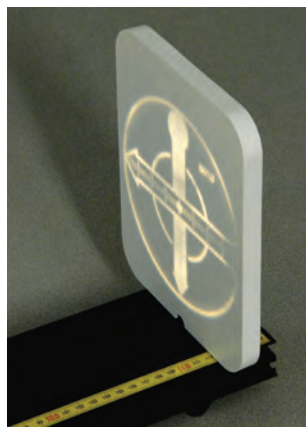
Basic Optics System OS-8515C p. 288

Basic Optics Components

Basic Optics Viewing Screen

OS-8460

This white plastic screen is used with the Basic Optics System. The screen snaps into the optics bench, and the position of the screen can be read directly on the bench scale. Also fits the Dynamics Track Optics Carriages (OS-8472A on page 306) for use with a Dynamics Track.



Order Information

Basic Optics Viewing Screen OS-8460

Basic Optics Spares Kit

OS-8510

All parts are organized in a plastic case for easy storage.



The Basic Optics Spares Kit includes many of the small parts that are sometimes lost after student use. Also includes two replacement bulbs for the Light Source. Suitable for all versions of the Basic Optics System (OS-8515).

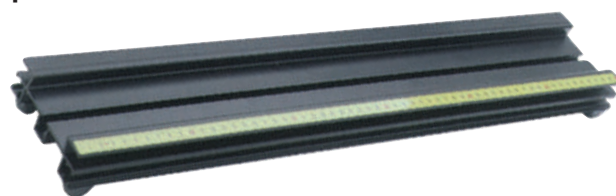
Includes:

- 10 W bulb for Basic Optics Light Source OS-8470 or OS-8517 (2)
- 6-32 1-1/2" Screw for the Basic Optics Light Source OS-8517A (8)
- 3/8" Screw for optics accessories (6)
- 3/8" Brass thumbscrew for optics track brackets (4)
- 1/4-20 1/2" Nylon thumbscrews (8)
- 1/4-20 Square nuts (20)
- Nylon washers (6)
- 1/4-20 9/16" Round steel thumbscrews (4)
- 1/4-20 3/8" Round steel thumbscrews (4)
- 6-32 5/8" Round steel thumbscrews (6)
- 6-32 3/8" Round steel thumbscrews (4)
- 4-40 5/16" Round steel thumbscrews (4)
- 6-32 3/16" Round steel thumbscrews (4)
- Replacement rubber feet for optics bench (6)
- Replacement rubber feet for Basic Optics Light Source OS-8517 (15)
- Replacement screws for Basic Optics Light Source OS-8470 (4)
- Plastic storage box

Order Information

Spares Kit OS-8510

Optics Benches



Optics Bench (60 cm)

OS-8541

This short optical bench is for experiments in polarization and spectrophotometry.

1.2 m Optics Track

OS-8508

The 1.2 m Optics Track is the perfect length for studying the inverse square law, diffraction/interference patterns, and the behavior of light traveling through lenses or off of curved mirrors. It is made of extruded aluminum and has a wide central channel for PASCO optics components, such as mounted lenses, mirrors, and light boxes.

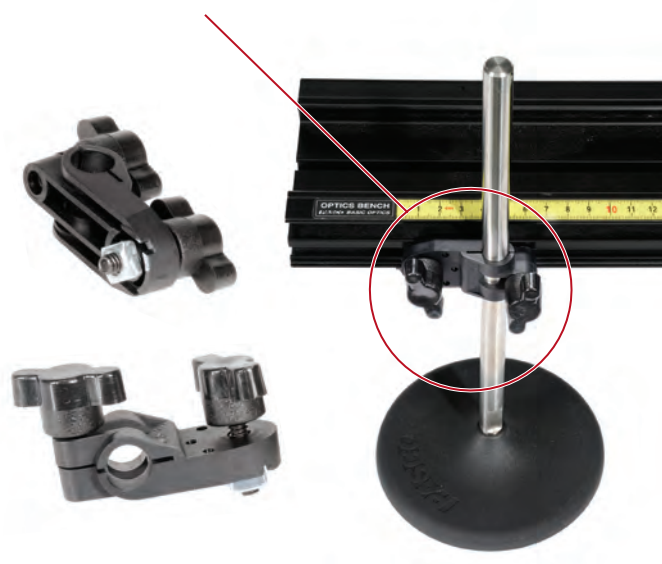
Order Information

Optics Benches (60 cm) OS-8541
1.2 m Optics Track OS-8508

Optics Bench Rod Clamp (set of 2)

OS-8479

Rod Clamps are used to elevate Basic Optics benches to match the height of various light sources.



Includes:

- Rod Clamps (2)

Order Information

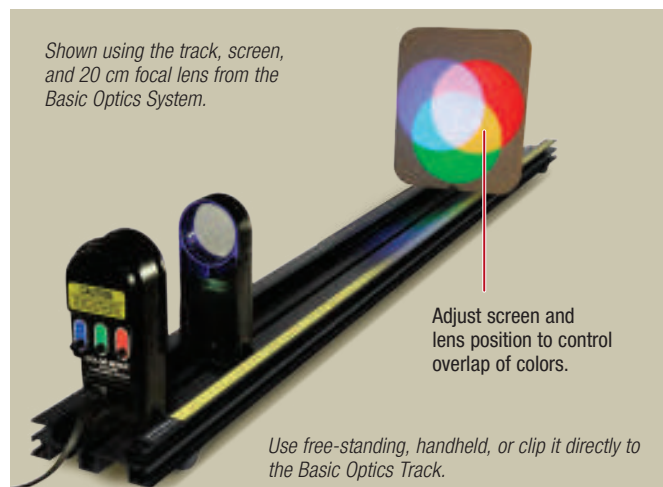
Optics Bench Rod Clamp (set of 2) OS-8479
Shown in use with:
Round Base with Rod ME-8270

Color Mixer

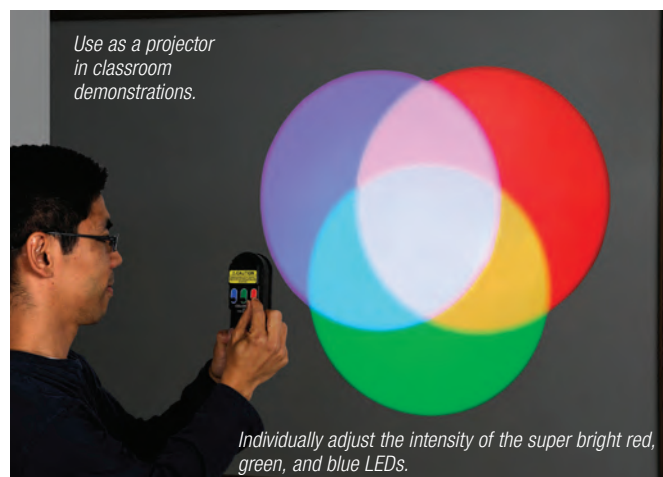
OS-8496

- Demonstrates additive color mixing
- Accessory to Basic Optics System

Three independently controllable LEDs offer a simple way to explore light and color. The Color Mixer can be used as both a demonstration tool and as an expansion piece to the Basic Optics System.



The intensity of the red, green and blue LEDs of the Color Mixer can be individually adjusted to easily vary the intensity of any or all of them. Demonstrating additive color mixing is as simple as using any flat surface to project the light upon.



Includes:

- Tri-color light source
- Power supply



Color Mixer Accessory Kit

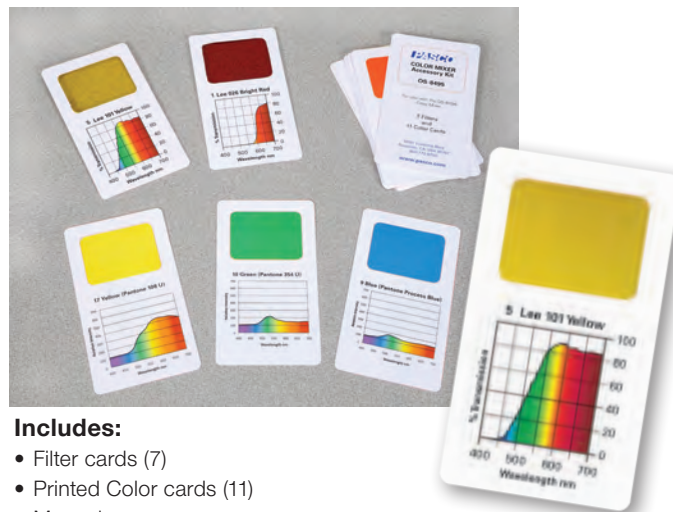
OS-8495

- Accessory to the Color Mixer
- 7 filter cards
- 11 printed color cards
- Manual with 9 lab activities



The red filter's spectral chart shows it transmits only red light. Students observe that the blue and green circles disappear and the overlapping areas of magenta, yellow, and white become red.

The Color Mixer Accessory Kit has 18 cards (64 mm x 89 mm) and a manual with 9 associated lab activities. Each of the 7 filter cards has its transmission spectrum printed on the card. Each of the 11 color cards is printed with a different color and its associated relative reflectance spectrum. Printed colors are defined by the Pantone color matching system. This accessory kit was designed especially for use with the Color Mixer.



Includes:

- Filter cards (7)
- Printed Color cards (11)
- Manual

Order Information

Color Mixer Accessory Kit OS-8495

Order Information

Color Mixer OS-8496

Optics of the Human Eye

Human Eye Model

OS-8477A

- ▶ Classic eye model at an affordable price
- ▶ 3-D working model of the human eye

Features:

▶ Working Model of the Human Eye:

Two lenses are used to form images on the retina. Sealed tank holds water to simulate the vitreous humor. Size and orientation of the illuminated object can be easily measured.

▶ Study the Optics of Normal Vision and Vision Correction:

Use the included plastic lenses to create images for normal vision, far-sightedness, near-sightedness, and astigmatism. Additional lenses are placed in front of the eye to correct for vision problems.

▶ Fixed Corneal Lens and Interchangeable Crystalline Lens:

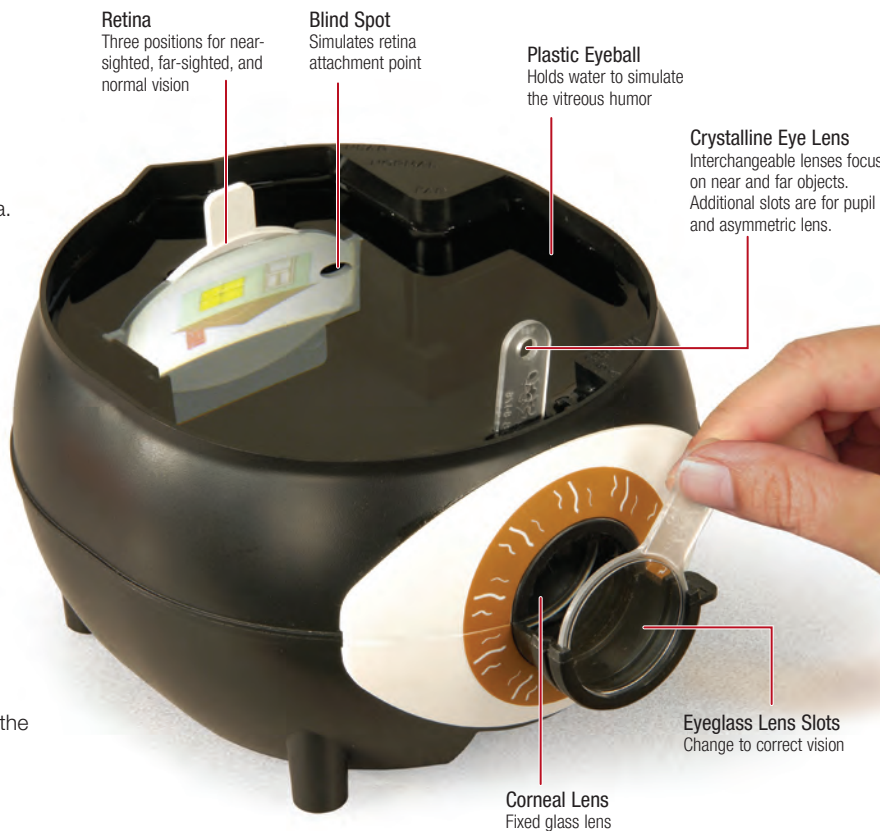
The crystalline lens is surrounded by water (vitreous humor). By changing the crystalline lens, the eye can focus on both near and far objects.

▶ Movable Retina:

Three positions demonstrate near-sightedness, far-sightedness, and normal vision.

▶ Variable Pupil Size:

Students can observe the change in brightness and clarity of the image as the pupil size is reduced.



Pupil Aperture



Use the Pupil Aperture to reduce the pupil size or to change the shape to a "cat's eye."



Use the Eye Model to image any illuminated picture, or use it with the Basic Optics System and Eye Model Bracket on page 297.

Includes:

- Molded Plastic Eyeball
- Plastic Lenses (2 sets of 6)
- Pupil Aperture
- Retina Screen
- Optics Caliper
- Adjustable Focal Length Lens with Syringe, Tubing, and 2 Flexible Lenses
- Experiment Manual



Specifications:

Focal Lengths in Air of Plastic Lenses: +62 mm (+16d), +120 mm (+8.3d), +400 mm (+2.5d), -1000 mm (-1.0d), -128 mm (-7.8d) cylindrical, +307 mm (+3.26d) cylindrical

Corneal Lens Focal Length in Air: +140 mm (+7.1d)

Dimensions: 15 cm x 17 cm x 10 cm high

Order Information

Human Eye Model..... OS-8477A

Recommended:

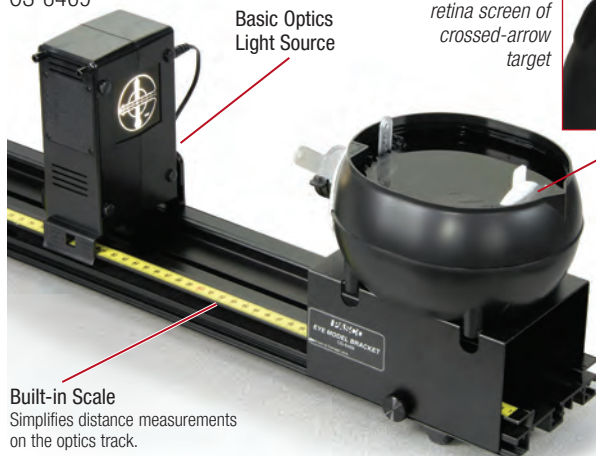
Basic Optics Light Source OS-8470 p. 291

Lens Replacement Set OS-8476 (includes lenses, screen, and pupil)

Optics Caliper OS-8468 p. 297

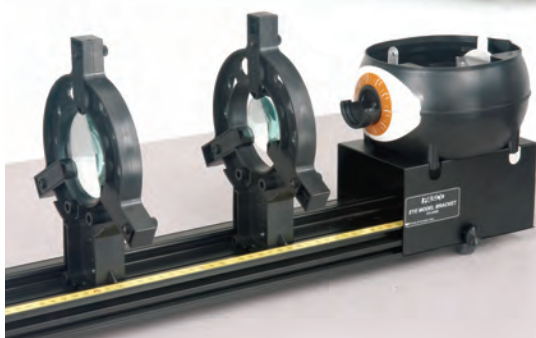
Eye Model Bracket

OS-8469



The Eye Model Bracket allows the Human Eye Model to be used with the Basic Optics System (OS-8515C). The bracket holds the Eye Model securely on the track at the correct optical height.

The illuminated crossed-arrow target on the Basic Optics Light Source makes the perfect object. Easily measure object and image distances, as well as the size of the object and image for calculations of magnification.



Eye Model and Bracket are shown with a telescope made using two Adjustable Lens Holders (OS-8474) and accessory lenses. Students can see the image through the telescope with their own eyes, and then place the Eye Model on the track and see the same image projected on the retina screen.

Includes:

- Bracket
- Two 1/4-20 thumb screws with nuts (2)

Order Information

Eye Model Bracket.....	OS-8469
Shown in use with:	
Basic Optics System	OS-8515C
Human Eye Model.....	OS-8477A

Optics Caliper

OS-8468

- ▶ Glow-in-the-dark tips
- ▶ Waterproof

This lightweight plastic caliper is perfect for measuring images in the dark. Simply span the object and then use a scale to measure the distance. For approximate measurements, use the built-in cm scale on the calipers.



The tips of the caliper glow in the dark. Activate with an incandescent or UV lamp.



Use the Optics Caliper to measure image sizes in the Human Eye Model. Glow-in-the-dark tips are activated using a UV light source.

Order Information

Optics Caliper (set of 5)	OS-8468
---------------------------------	---------

Optics of the Human Eye

Adjustable Focal Length Lens

OS-8494

Using the syringe to adjust the amount of water in the lens changes the curvature of the clear flexible membranes and, therefore, the focal length of the lens.



Demonstrate accommodation:

Show how the eye lens changes focal length by changing its surface curvature.

See page 280 for use with Basic Optics System.



Includes:

- 10 mL Syringe
- 1 ft. Silicon Tubing
- Lenses (2)

Order Information

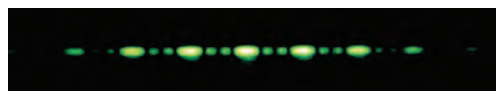
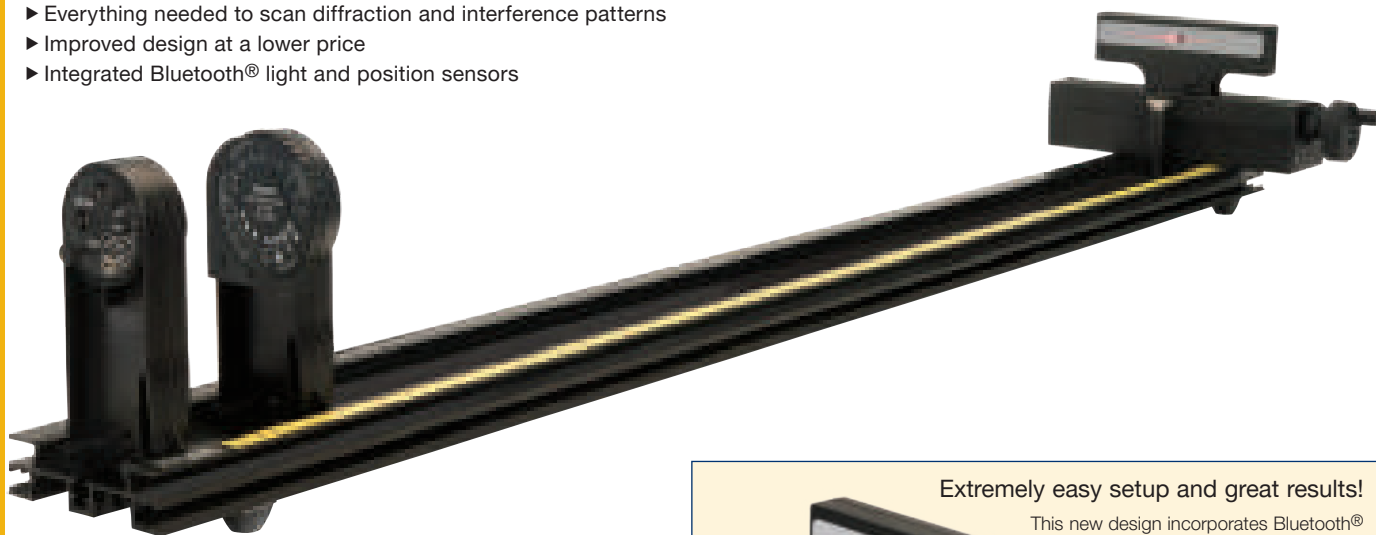
Adjustable Focal Length Lens.....	OS-8494
Shown in use with:	
Human Eye Model.....	OS-8477A

Wireless Diffraction System

Wireless Diffraction System with Track

OS-8439

- ▶ Everything needed to scan diffraction and interference patterns
- ▶ Improved design at a lower price
- ▶ Integrated Bluetooth® light and position sensors

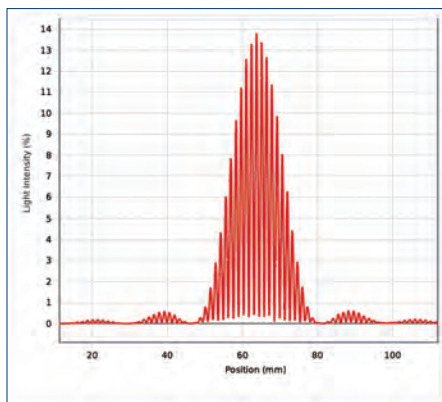


Four slits illuminated with a green laser reveal the expected two minor maxima.

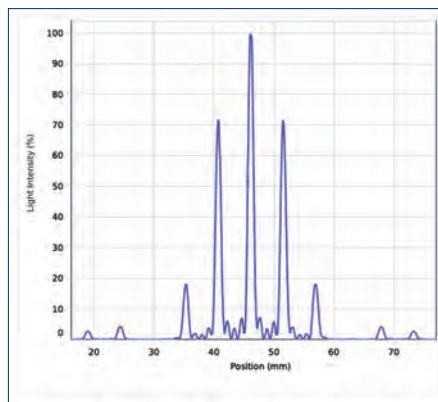


Extremely easy setup and great results!

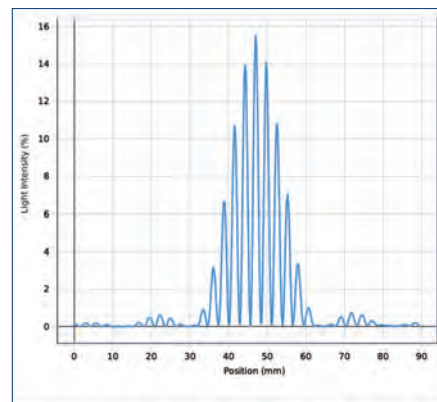
This new design incorporates Bluetooth® light and position sensors into one convenient unit. Smooth hand-cranked scanning is achieved with a precision worm gear. The reduced number of parts makes assembly and alignment very easy.



This system works so well that many orders of diffraction can be detected.



The high resolution enables students to see the three minor maxima when scanning five slits.



Actual double-slit graph of Intensity vs. Distance looks just like the textbook illustrations.

Includes:

- Red Diode Laser: OS-8525A
- Diffraction Slits: OS-8442
- Wireless Diffraction Scanner: OS-8441
- 1.2 m Optics Track: OS-8508

Order Information

Wireless Diffraction System with Track OS-8439

Recommended:

Green Diode Laser OS-8458B p. 303

Wireless Diffraction Scanner

OS-8441

- Real-time Intensity vs. Position graphs
- Single-slit diffraction
- Double-slit interference
- Precision hand crank for smooth, consistent travel
- Light sensor aperture adjustment
- 0.01 mm position measurement resolution
- Wireless Bluetooth® Low Energy technology

The Wireless Diffraction Scanner combines a position sensor with a light sensor for scanning diffraction patterns. Compatible with PASCO optics benches and dynamics track adapter carriages, the Wireless Diffraction Scanner is the perfect update to existing PASCO-based optics systems that use the snap-in optics components. An included aperture setting allows for the adjustment of width-measurement resolution and light attenuation. A hand crank allows for smooth scanning of diffraction patterns. And, with its wireless design, smooth scans are achieved effortlessly!

This unit enables students to scan many diffraction and interference patterns during one lab period. They can study the differences caused by changing the slit width, slit separation, and number of slits. And, by comparing patterns created by a Red Diode Laser to those of a Green Diode Laser, they can study the difference caused by a change in wavelength.

Data collection is performed using either PASCO Capstone or SPARKvue software (required). Connect to software using either USB or Bluetooth Low Energy.



Specifications:

Aperture Range: 0.1 mm to 1.5 mm

Position Resolution: .01 mm

Scan Travel: 155 mm

Connectivity: USB and Bluetooth® 5.2

Battery Type: Rechargeable LiPo (1000 mA)

Includes:

USB Charging Cable

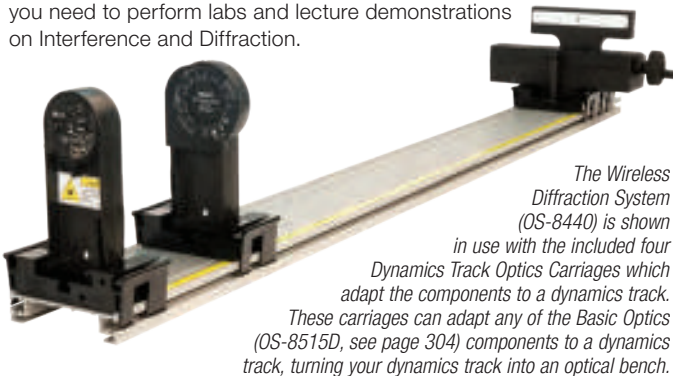
Order Information

Wireless Diffraction Scanner.....OS-8441

Wireless Diffraction System

OS-8440

If you already have a PASCO Optics Track, or a PASCO Dynamics Track, the Wireless Diffraction System contains all the equipment you need to perform labs and lecture demonstrations on Interference and Diffraction.



Includes:

- Red Diode Laser: OS-8525A
- Wireless Diffraction Scanner: OS-8441
- Diffraction Slits: OS-8442
- Dynamics Track Optics Carriages (Set of 4): OS-8472A

Order Information

Wireless Diffraction System	OS-8440	
Required:		
1.2 m Optics Track.....	OS-8508	p. 294
OR		
1.2 m Aluminum Dynamics Track.....	ME-9493	p. 106
OR		
PASTrack.....	ME-6960	p. 118

Diffraction Slits

OS-8442

The Diffraction Slits include a selectable wheel with 16 interference patterns designed to match the height of the PASCO Diode Lasers. The slits are constructed using vacuum deposited chromium on glass and clip directly to a PASCO Optics Bench.



Specifications:

Compatible System:

PASCO Optics Track

Slit Width Tolerance (mm): ± 0.005

Slit Spacing Tolerance (mm): ± 0.010 (spacing > 0.125)

Slit Spacing Tolerance (mm): ± 0.005 (spacing < 0.125)

Printing Type: Vacuum-deposited Chromium on glass

Single Slit Width (mm): $a = 0.02, 0.04, 0.08, 0.16$

Double Slit Width, Separation (mm):

$a = 0.04, d = 0.25$; $a = 0.04, d = 0.50$

Double Slit Width, Separation (mm):

$a = 0.08, d = 0.25$; $a = 0.08, d = 0.50$

Multiple Slits (mm): 2, 3, 4, 5 ($a = 0.04, d = 0.125$)

Patterns: Square, Hexagonal, Dots, Holes

Order Information

Diffraction Slits.....OS-8442

Diffraction

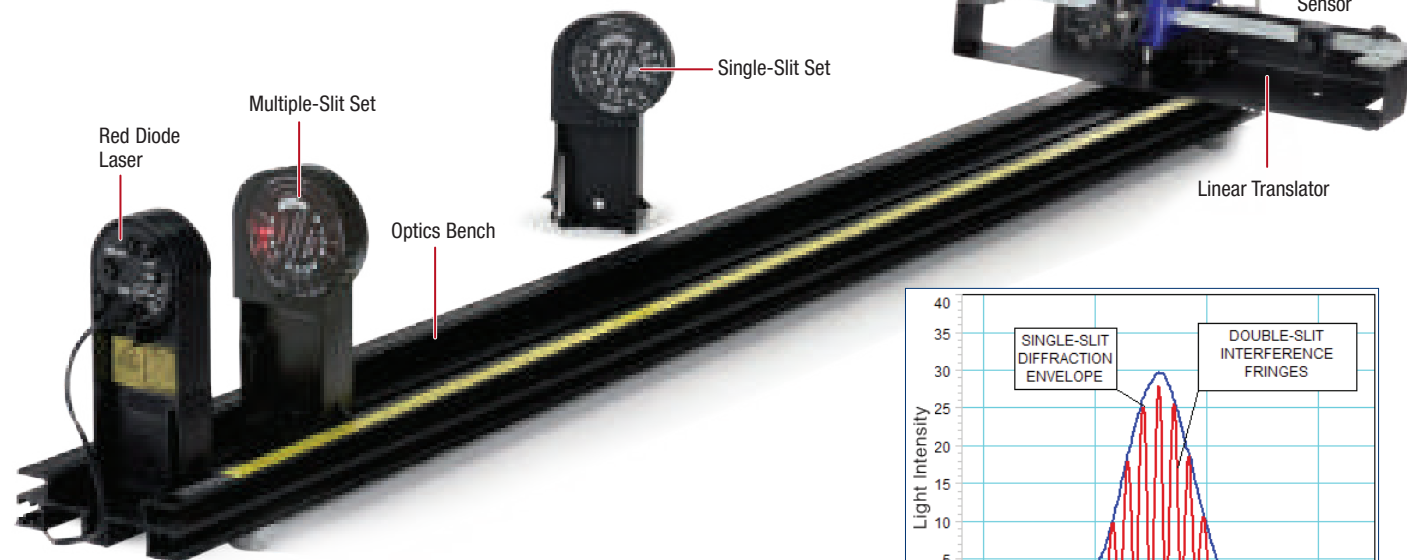
Sensor-Based Diffraction System

OS-8452

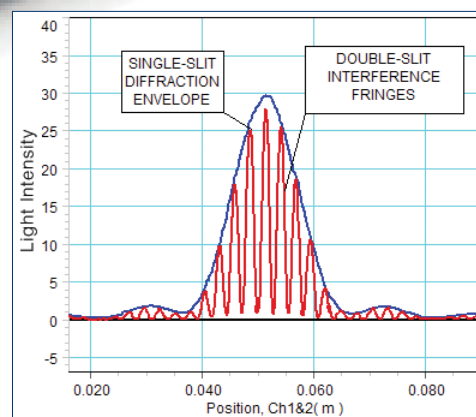
- ▶ Vacuum-deposited chromium on glass
- ▶ Single-slit diffraction

- ▶ Double-slit interference
- ▶ Real-time intensity graphs

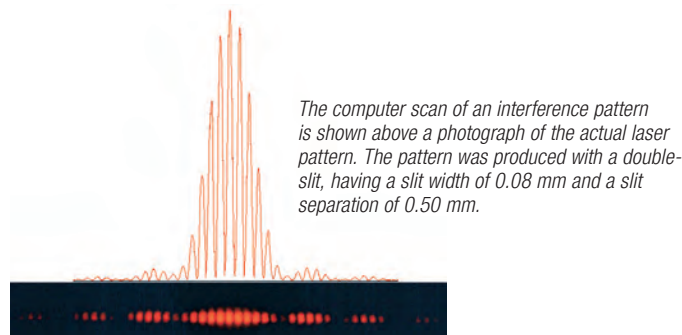
The Sensor-Based Diffraction System enables students to scan many diffraction and interference patterns during one lab period. They can study the differences caused by changing the slit width, slit separation, and number of slits. And, with the addition of the Green Diode Laser, they can study the difference caused by changing the wavelength.



Scanning with the Linear Translator (on page 303): In this unique scanning system, the diffraction pattern is scanned using a Light Sensor attached to a Rotary Motion Sensor. As the wheel on the Rotary Motion Sensor is rotated by hand, the Rotary Motion Sensor moves along a gear rack (called the Linear Translator). Students make the association between the diffraction pattern they see and the real-time graph of the light intensity vs. position.



Computer scan of a single-slit and double-slit having the same slit width



The computer scan of an interference pattern is shown above a photograph of the actual laser pattern. The pattern was produced with a double-slit, having a slit width of 0.08 mm and a slit separation of 0.50 mm.

Includes:

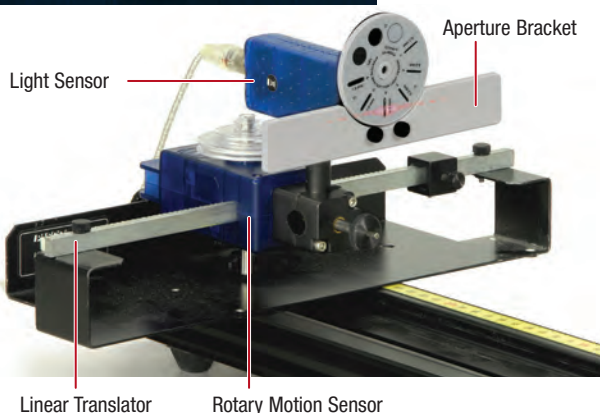
- Red Diode Laser: OS-8525A
- Linear Translator: OS-8535A
- Aperture Bracket: OS-8534A
- 1.2 m Optics Track: OS-8508
- Precision Diffraction Slits: OS-8453



For components and accessories, see pages 302-303.

Order Information

Sensor-Based Diffraction System (with Optics Bench).....	OS-8452	
Required for use with ScienceWorkshop:		
Light Sensor	CI-6504A	p. 30
Rotary Motion Sensor	CI-6538	p. 26
Required for use with PASPORT:		
PASPORT High Sensitivity Light Sensor	PS-2176	p. 42
PASPORT Rotary Motion Sensor	PS-2120A	p. 35
Recommended:		
Green Diode Laser	OS-8458B	p. 303



Diffraction Optics Kit

OS-8531A

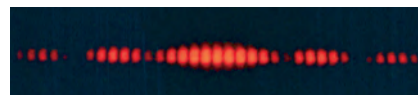
Add this kit to the Basic Optics System to allow the investigation of a wide variety of diffraction slit patterns. The slits are constructed using vacuum-deposited chromium on glass.

The following patterns are included:

- Single Slit (four variations)
- Variable Width Single Slit
- Double Slit (four variations)
- Multiple Slit (3,4,5)
- Single Slit/Double Slit Comparison
- Variable Spacing Double Slit



Single Slit Pattern ($a = 0.04 \text{ mm}$)



Double Slit Pattern ($a = 0.08 \text{ mm}$, $d = 0.05 \text{ mm}$)

CLASS 2 LASER PRODUCT
LASER LIGHT – DO NOT
STARE INTO BEAM



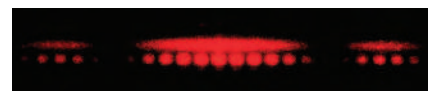
Red Diode Laser

Slit Accessory

Snap into position on the bench for automatic slit alignment with laser. Rotate disk to select a different pattern.



4-Slit Pattern ($a = 0.04 \text{ mm}$, $d = 0.125 \text{ mm}$)



Single/Double Slit Comparison

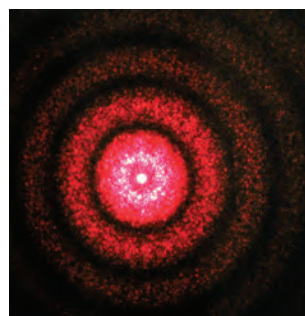
Easy Laser Alignment

The laser beam can be aimed through the slits using two thumb screws. Once the beam is aligned, either the laser or the slits can be removed from the optics bench and returned to the bench without re-aligning the beam.

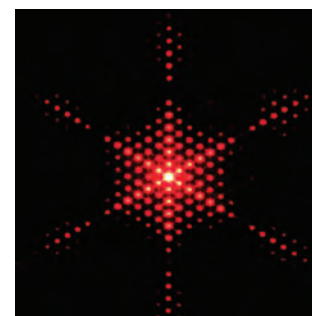


Change Slits in the Dark Without Re-aligning Everything

The slit wheels eliminate the frustration of trying to change the slits in a darkened room. Simply rotate to the next positive click to lock a different slit into position. The alignment of the disk only has to be done once. After that, all the slits on that wheel will be aligned.



Circular Diffraction Pattern

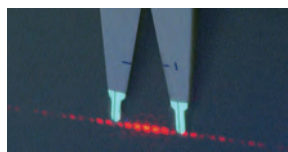


Hex Diffraction Pattern

Optics Caliper

OS-8468

This lightweight plastic caliper is perfect for measuring images in the dark. Simply span the object and then use a scale to measure the distance. For approximate measurements, use the built-in cm scale on the calipers. See page 297 for more information.



Order Information

Optics CaliperOS-8468

Includes:

- Red Diode Laser: OS-8525A
- Precision Diffraction Slits: OS-8453



For components and accessories, see pages 302-303.

Order Information

Diffraction Optics Kit.....	OS-8531A	
Required:		
1.2 m Optics Track.....	OS-8508	p. 294
Basic Optics Viewing Screen.....	OS-8460	p. 294
Recommended:		
Green Diode Laser.....	OS-8458B	p. 303

Diffraction Components

Precision Diffraction Slits

OS-8453

- ▶ Vacuum-deposited chromium on glass
- ▶ Single-slit and double-slit wheels

OS-8453 includes two slit wheels with holders designed to match the height of the slits to the height of the diode laser. All components clip directly to the Optics Bench from the Basic Optics System OS-8515C. The slit wheels eliminate the frustration of trying to change the slits in a darkened room. To change the slit being illuminated by the laser, the slit wheel is simply rotated to the next positive click, which locks another slit into position.

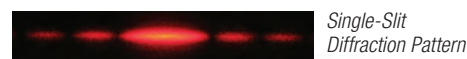
Shown in use with the Red OS-8525A and Green OS-8458 Diode Lasers.

Simply rotate the wheel to select the desired slit. Each position locks into place, making it easy to use, even in the dark.

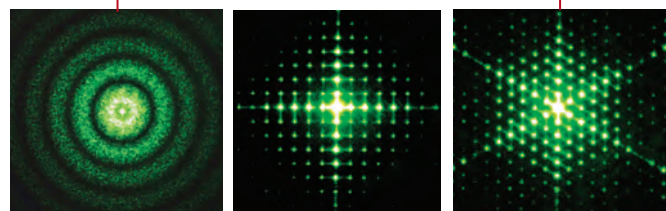
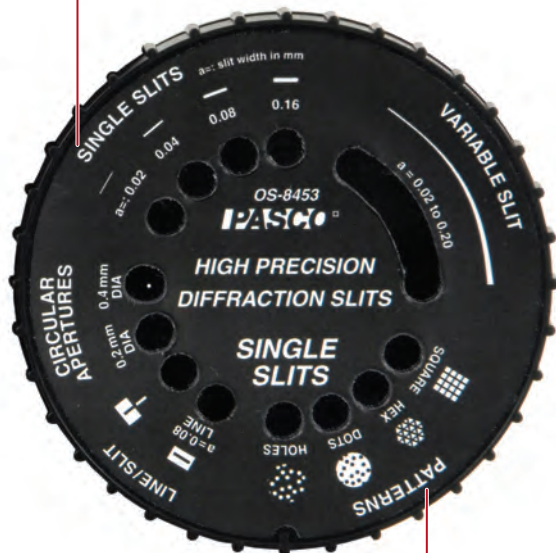


CLASS 2 LASER PRODUCT
LASER LIGHT – DO NOT
STARE INTO BEAM

The Single-Slit Wheel includes four single slits of different widths, two circular apertures, one line/slit comparison, one opaque line, a variable width slit, and four patterns.



Single-Slit
Diffraction Pattern



The Circular Diffraction pattern has the same dimensions for both the dots and the holes.

The diffraction geometry represents the structure of the Square and Hex patterns.

Includes:

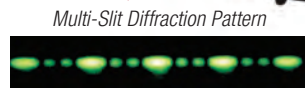
- Single-Slit Wheel with Holder
- Multiple-Slit Wheel with Holder



The Multiple-Slit Wheel includes four double slits, a set of four multiple slits having the same slit width and separation (2, 3, 4, and 5 slits), four slit comparisons, and a variable double slit.



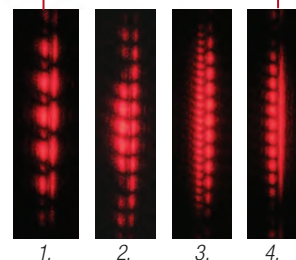
Double-Slit
Diffraction Pattern



Multi-Slit Diffraction Pattern

The comparisons have two slits illuminated by the same red laser beam, so that the patterns can be viewed side by side.

1. Two-slit and three-slit comparison
2. Different slit widths
3. Different slit separation
4. Single-slit and double-slit



Order Information

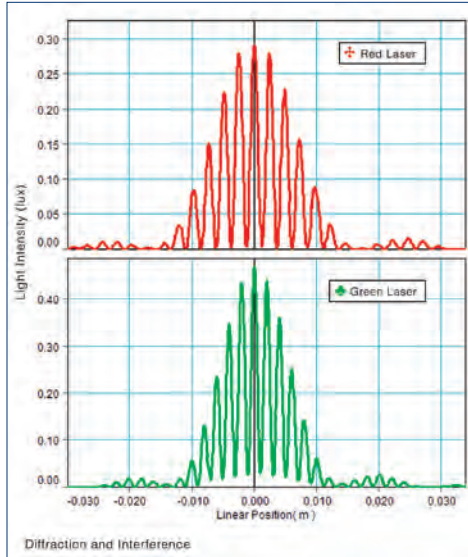
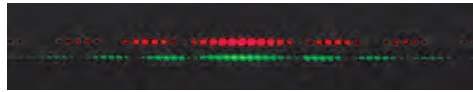
Precision Diffraction Slits	OS-8453	
Recommended:		
Basic Optics System	OS-8515C	p. 288
Red Diode Laser	OS-8525A	p. 303
Green Diode Laser	OS-8458B	p. 303

Red Diode Laser

OS-8525A

These unique diode lasers take the frustration out of aligning the laser beam with the diffraction slits. With both lasers, you can demonstrate the effect of changing wavelength on the diffraction and interference patterns.

A red laser beam was passed through a double slit. Then the Red Diode Laser was replaced by the Green Diode Laser by simply pulling the Red Laser off the optics track and clipping the Green Laser into its place. The recorded patterns



from red and green lasers show clearly that the longer red wavelength is spread out more than the green.



The horizontal and vertical positions of the beam can be adjusted by turning the thumb screws on the back of the laser.



Demonstrate the effect of changing wavelength on the diffraction and interference patterns.

CLASS 2 LASER PRODUCT
LASER LIGHT – DO NOT STARE INTO BEAM

Specifications:

Output Power: <1 mW

Wavelength: 650 nm (OS-8525); 515 nm (OS-8458B)

Power Supply: 9 V adapter (included)

Order Information

Red Diode Laser	OS-8525A
Green Diode Laser	OS-8458B

Linear Translator

OS-8535A



The Linear Translator transforms a Rotary Motion Sensor into a linear motion device. The toothed rack of the Linear Translator fits into the slot in the side of the Rotary Motion Sensor. As the Rotary Motion Sensor pulley is rotated by hand, the Rotary Motion Sensor moves along the rack. Rotary Motion Sensor not included.

Specifications:

Resolution for Rotary Motion Sensor: 0.055 mm (CI-6538);
0.020 mm (PS-2120)

Maximum Travel: 20 cm

Order Information

Linear Translator	OS-8535A
-------------------------	----------

Aperture Bracket

OS-8534A

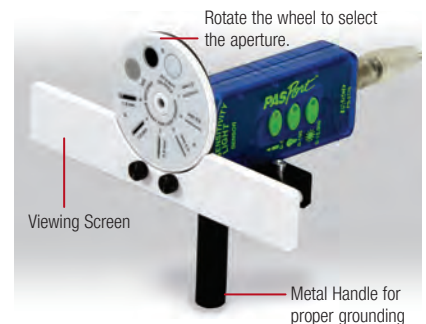
The Aperture Bracket acts as a mask for a light sensor. The wheel is rotated to select different size slits, defining the spatial resolution. Narrow slits are used to scan diffraction patterns having fine detail. Wider slits are used to let in more light when scanning dimmer patterns. The diffuser selection is used for inverse square law experiments.

Specifications:

Six Slits: From 0.1 mm to 1.5 mm width

Open Aperture:

No reduction in intensity
10% transmittance
diffuser



Includes:

- Aperture Bracket with Screen
- Metal Handle
- Accessory Holder

Order Information

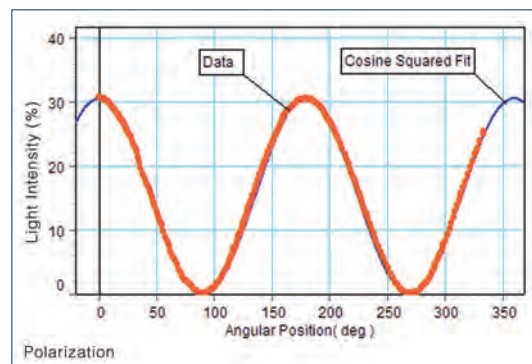
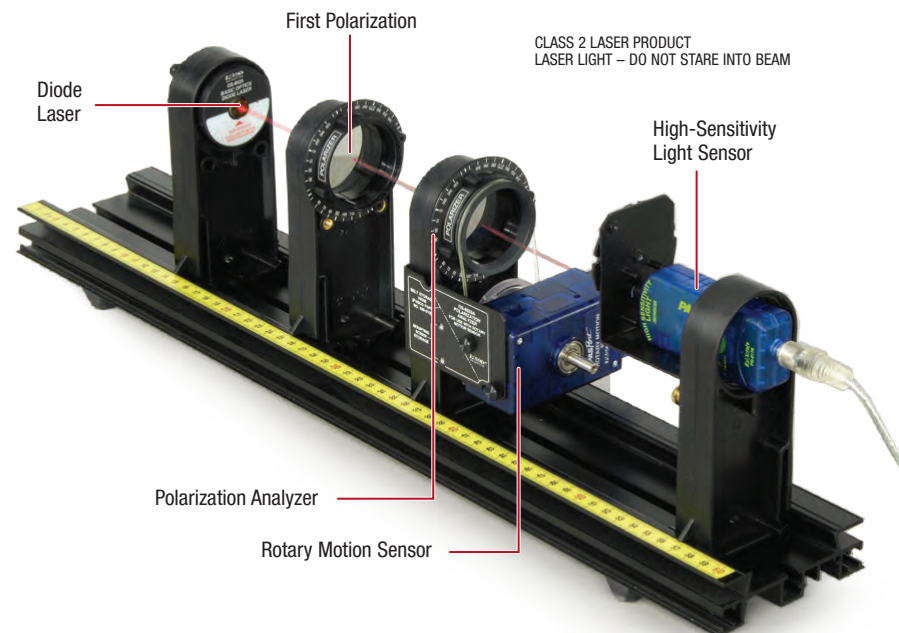
Aperture Bracket	OS-8534A
------------------------	----------

Polarization

Polarization Analyzer

OS-8533A

Students can confirm Malus' Law of Polarization by using the Polarization Analyzer with the Basic Optics System. All components mount directly to PASCO's Basic Optics Bench OS-8541. The Rotary Motion Sensor is used to measure the angle between the two polarizing disks. The Light Sensor measures the intensity of light that passes through both polarizers.



Shown with Optics Bench OS-8541, 60 cm track

As the polarizer is rotated, the intensity of the light varies as the square of the cosine of the angle between the two polarizers.



Includes:

- Polarizer Disks (2)
- Polarizer Holder
- Aperture Bracket
- Accessory Holder with Mounting Bracket
- Accessory Holder for Aperture Bracket
- Retarder Disk

Order Information

Polarization Analyzer OS-8533A

Required:

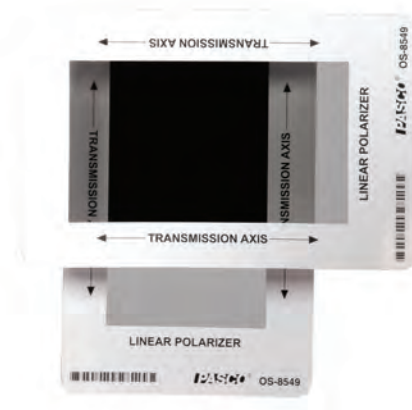
PASPORT Rotary Motion Sensor	PS-2120A	p. 35
PASPORT High Sensitivity Light Sensor	PS-2176	p. 42
Basic Optics System	OS-8515C	p. 288
Red Diode Laser	OS-8525A	p. 303

See complete experiment on page 385.

Linear Polarizer (2 pack)

OS-8549

This pair of rectangular polarizers are mounted in cardboard frames. The polarizing film dimensions are 3.5" x 6". Includes two polarizers.



Order Information

Linear Polarizer (2 pack) OS-8549

Polarizer Set

OS-8473

This accessory set includes two polarizer disks and an optics holder. Rotate the polarizers relative to one another to view the effect on light intensity.



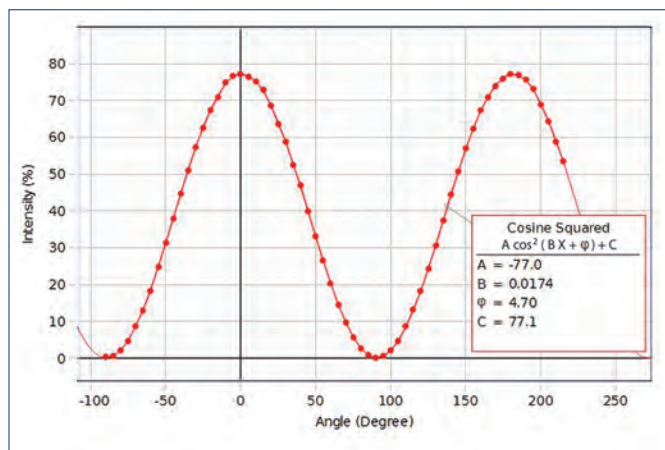
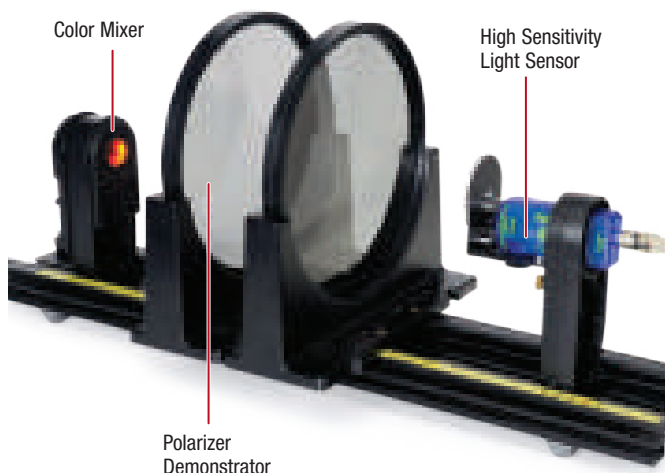
Order Information

Polarizer Set OS-8473

Polarizer Demonstrator

OS-9477A

Confirm Malus' Law using the Polarizer Demonstrator and a Light Sensor. The angle is read directly from the polarizer, which is marked in 5° increments. Any light source can be used, but the experiment works especially well with the Color Mixer, as shown here.



As the polarizer is rotated, the intensity of the light varies as the square of the cosine of the angle between the two polarizers.

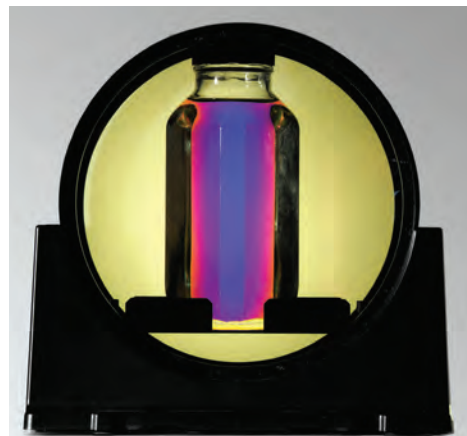
Includes:

- Round Polarizer Discs with Stands

Polarizer Demonstration Accessory

OS-8172

This accessory adds a central platform and diffuser to the Polarizer Demonstrator (OS-9477A). Put sugar water in one of the two supplied square glass bottles and put it on the platform between crossed polarizers. Use a desk lamp or Color Mixer (OS-8496) behind the diffuser and rotate one of the polarizers to see the sugar water change colors as the axis of polarization of different colors rotates to different angles.



Demo with Karo® corn syrup shows wavelength dependence of optical rotation. The light source used was a compact florescent (not included).



Includes:

- Square Glass Bottles (2)
- Metal Stand for Bottles
- Diffusion Screen



Order Information

Polarizer Demonstration Accessory	OS-8172
Required:	
Polarizer Demonstrator	OS-9477A
Suggested:	
Color Mixer	OS-8496 p. 295

Order Information

Polarizer Demonstrator	OS-9477A
Shown in use with:	
Optics Benches (60 cm)	OS-8541 p. 294
Aperture Bracket	OS-8534A p. 303
Color Mixer	OS-8496 p. 295
PASPORT High Sensitivity Light Sensor	PS-2176 p. 42

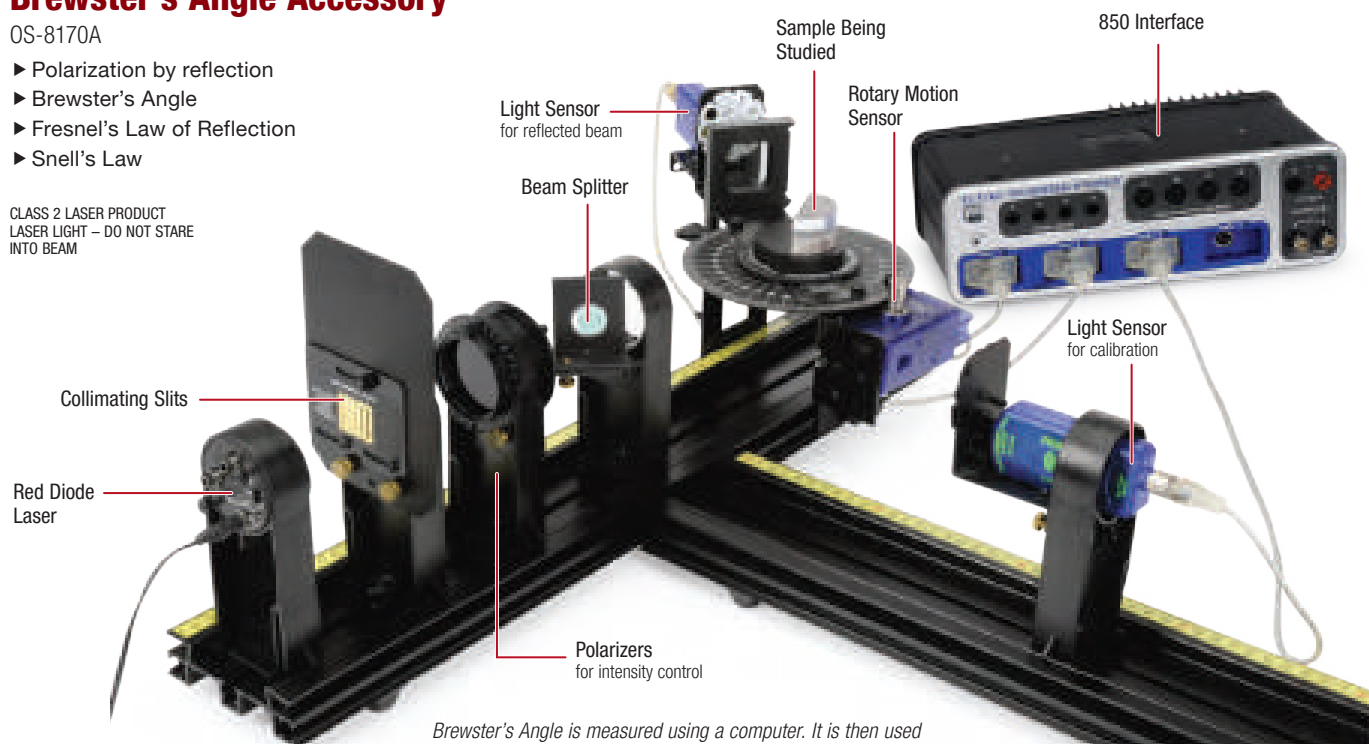
Polarization

Brewster's Angle Accessory

OS-8170A

- Polarization by reflection
- Brewster's Angle
- Fresnel's Law of Reflection
- Snell's Law

CLASS 2 LASER PRODUCT
LASER LIGHT – DO NOT STARE
INTO BEAM



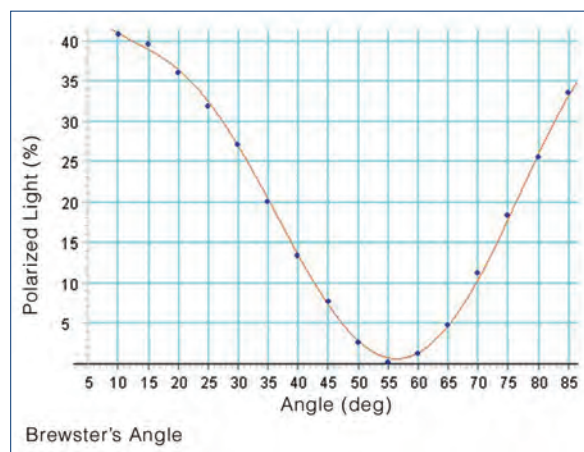
Brewster's Angle is measured using a computer. It is then used to calculate the index of refraction of the reflecting material.

When light reflects off a nonconducting material, the reflected light is partially polarized. The amount of polarization depends on the incident angle and the index of refraction of the reflecting material. The incident angle that gives maximum polarization is called Brewster's Angle.

Light from a diode laser (wavelength = 650 nm) is reflected off the flat side of an acrylic semicircular lens. The reflected light passes through a polarizer and is detected by a Light Sensor. The angle of incidence is measured by a Rotary Motion Sensor mounted on the spectrophotometer table. The intensity of the reflected polarized light vs. incident angle is graphed to determine the angle at which the light intensity is a minimum. This is Brewster's Angle, which is used to calculate the index of refraction of acrylic.

The intensity of the reflected polarized light as a function of the incident angle; see Brewster's Angle Experiment on page 386.

Developed using original ideas from P.J. Ouseph, Professor of Physics at University of Louisville, KY: "Polarization of Light by Reflection and the Brewster Angle" by P.J. Ouseph, Kevin Driver, and John Conklin, Am. J. Phys. 69, 1166 (2001). This modification to the experiment was suggested by Cristian Bahrim and Wei-Tai Hsu in the American Journal of Physics article: "Precise measurement of the refractive indices for dielectrics using an improved Brewster angle method," Vol. 77, page 337 (2009).



Includes:

- Acrylic semicircular lens
- Lens platform
- Polarizers with holder (2)
- Analyzing polarizer
- Beam splitter



Order Information

Brewster's Angle Accessory OS-8170A
Basic Optics Beam Splitter OS-8171
For other required equipment, see the Brewster's Angle experiment EX-5544A on page 386.

Meter Stick Optics Complete System

OS-7052

PASCO's Meter Stick Optics Complete System includes all of the components needed to explore essential optics topics like image magnification, lens focal length, real and virtual images, combination of lenses, and so much more! This simple but robust system is designed to fit directly onto the included PASCO Aluminum Meter Stick, making measurements of object distance and image distance easy and straightforward for students.



Features:

- ▶ Bright, rechargeable LED light source
- ▶ Lenses mounted in holders to protect from damage
- ▶ Organized storage box for easy classroom management

Specifications:

- Lens Diameter:** 30 mm
- Lens Focal Lengths:** +100 mm, +200 mm, -150 mm
- Light Source Peak Wavelength:** 520 nm to 540 nm
- Height of Optical Axis:** 9.5 cm
- Viewing Screen Dimensions:** 16.5 cm x 14.0 cm
- LED Light Source Battery:** USB Rechargeable Lithium Polymer 3.7 V 1000 mAH
- Aluminum Meter Stick Dimensions:** 6.95 mm x 28.0 mm x 1.0 mm

Order Information

Meter Stick Optics Complete System	OS-7052
Available Separately:	
Meter Stick Optics Light Source	OS-7054
Meter Stick Optics Component Holder	OS-7055
Meter Stick Optics Viewing Screen	OS-7056
Meter Stick Optics Lens Set	OS-7057

The rechargeable LED light source provides long-lasting battery life and is bright enough to form clear images in a fully-lit classroom! The component holders and the viewing screen mount firmly on the meter stick, but can also be easily moved along the length of the meter stick. This makes the formation of real images easy to find and measure.

The high-quality lenses are clearly labeled and held firmly inside component holders. Using the built-in holding tabs, the lenses can be quickly exchanged in the component holders. Each lens comes with built-in standoffs to protect the lens surface from scratching and scuffing when placed flat on a tabletop.

Includes:

- Aluminum Meter Stick
- Meter Stick Optics Light Source OS-7054
- Meter Stick Optics Component Holder (2) OS-7055
- Meter Stick Optics Viewing Screen OS-7056
- Lens, -150 mm; +100 mm; +200 mm
- Storage Box

Meter Stick Optics Components Kit

OS-7053

PASCO's Meter Stick Optics Components Kit includes all the components of the Meter Stick Optics Complete System, except for the meter stick.

Includes:

- Meter Stick Optics Light Source OS-7054
- Meter Stick Optics Component Holder (2) OS-7055
- Meter Stick Optics Viewing Screen OS-7056
- Lens, -150 mm; +100 mm; +200 mm
- Storage Box



Specifications:

- Designed to be used with PASCO's Aluminum Meter Stick:** 6.95 mm x 28.0 mm x 1.0 mm
- LED Light Source Battery:** USB Rechargeable Lithium Polymer 3.7 V 1000 mAH

Order Information

Meter Stick Optics Components Kit	OS-7053
---	---------

Optics Components
Kit shown in included
storage box.



Ray Optics

Basic Optics Light Source

OS-8470

- ▶ One, three, or five parallel rays
- ▶ Three primary color source
- ▶ Crossed arrow object and point source

The Basic Optics Light Source is an excellent source for a variety of optics experiments. A single 10-watt quartz-halogen bulb provides bright, easy-to-see illumination without a lot of heat. By turning the box to a different side, it becomes a:

- Crossed Arrow Object with Metric Scale: ideal for showing images, focal point, and magnification.
- Bright Point Source: The very small filament of the halogen bulb provides an excellent point source for experimenting with shadows or the Inverse Square Law.
- Three Primary Colors Source: The red, green, and blue filters provide three rays of light that are easily combined with a lens for color mixing.
- One, Three or Five Ray Sources: Just rotate the knob in front of the light source to vary the number of rays produced.



Rotate the selector knob to choose between rays (1, 3, or 5) or the primary color mask.

The Basic Optics Light Source provides a point source and an extremely bright crossed arrow target. Use free-standing or easily clip directly to Basic Optics Track.



Includes:

- Universal AC Adapter
- Spare Bulb (stored under access cover)

Order Information

Basic Optics Light Source OS-8470

Ray Optics Kit

OS-8516A

The Ray Optics Kit is a basic set of optic components for ray and color experiments.

Includes:

- Double-Convex Lens
- Double-Concave Lens
- Rhomboid
- Eye-Dropper
- Triangular mirror accessory with concave, convex, and plane reflective surfaces
- Hollow lens to fill with a liquid or use as an air lens



Order Information

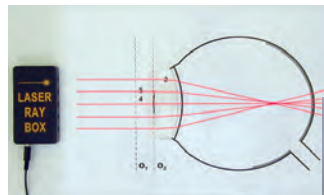
Ray Optics Kit OS-8516A

Ray Optics Laser System

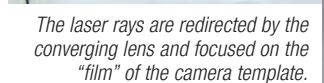
SE-8506

CLASS 2 LASER PRODUCT
LASER LIGHT –
DO NOT STARE INTO BEAM

- ▶ No need to dim the lights
- ▶ Wide variety of optical components
- ▶ Templates simulate real-world optical devices



The laser rays are focused in front of the retina by the myopic lens used with the human eye template.



The laser rays are redirected by the converging lens and focused on the "film" of the camera template.

This demonstration optics set uses a Laser Ray Box that has bright, well-defined rays because it uses lasers rather than an incandescent light source. The Laser Ray Box projects five parallel laser beams onto any flat surface. It contains five 1 mW diode lasers (wavelength 635 nm). The laser beams are spread out into clearly visible lines by cylindrical lenses inside the box.

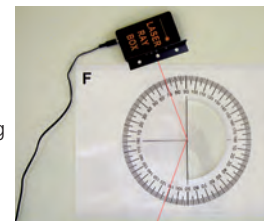
The ray box has a magnetic back for mounting on any steel board. The unit is powered by an included AC adapter.

This exceptional optics set includes six magnetically-backed templates that have guidelines showing where to put components to perform different demonstrations, including:

- ▶ Modeling the human eye and eyeglasses
- ▶ How a camera works
- ▶ Two types of telescopes
- ▶ Spherical aberration
- ▶ Refraction and reflection

Each component has a magnetic backing for mounting on any steel board.

The included protractor template can be used to demonstrate refraction.



Specifications:

Dimensions: 11 cm x 6 cm x 2 cm

Laser Ray Separation: 1.8 cm

Power Adapter: 3 VDC, 300 mA (included)

Wavelength: 635 nm

Includes:

- Laser Ray Box
- Laser Ray Mask
- Double-convex lenses (4)
- Double-concave lens
- Plano-concave lens
- "D" lenses (4.5 cm and 7.5 cm radius) (2)
- Plane, convex, and concave mirrors
- Right-angle prism
- Rectangle (6 cm x 10 cm)
- Optical fiber (2 cm x 20 cm)
- Templates (6)
- Steel whiteboard (56.5 cm x 41.5 cm)
- Most components are 10 cm tall and 1.7 cm thick.

Order Information

Ray Optics Laser System SE-8506

Laser Ray Box..... SE-8505

Mirage

SE-7302

These two concave mirrors create a real image of any object you place at the bottom. The image appears at the opening in the top and when students try to touch it, they find that it is only an image, not the real thing!



Includes:

- Concave mirror (14 cm diam.)
- Plastic frog

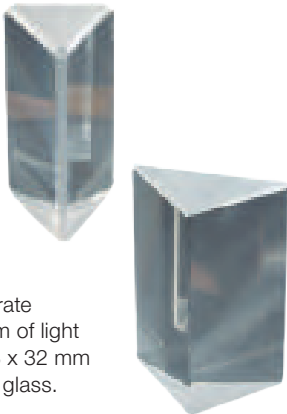
Order Information

Mirage.....SE-7302

Equilateral Prism

SE-9021A

Demonstrate the dispersion and refraction of white light with this high-quality glass prism. It's 30 mm on a side and 50 mm long.



Right Angle Prism

SE-9022A

Use this Right Angle Prism to demonstrate chromatic dispersion or to bend a beam of light by 90 degrees. It's 50 mm long with 23 x 32 mm sides, and made of high-quality optical glass.

Order Information

Equilateral Prism.....SE-9021A
Right Angle PrismSE-9022A

Demonstration Mirror, Convex

SE-7574

This convex large mirror comes with a convenient stand and is ideal for demonstrating the formation of real and virtual images. Diameter is 60 cm.



Demonstration Mirror, Concave

SE-7573

This concave large mirror comes with a convenient stand and is ideal for demonstrating the formation of real and virtual images. Diameter is 60 cm. Stand is included.

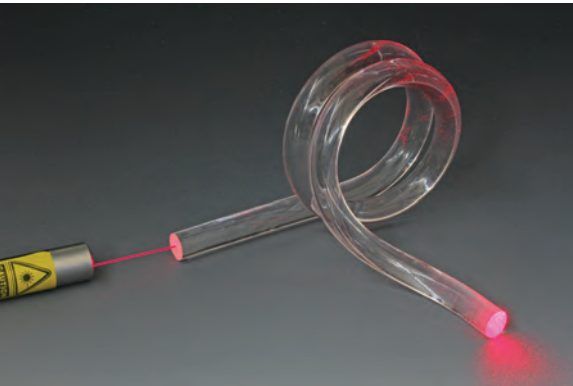
Order Information

Demonstration Mirror, Convex.....SE-7574
Demonstration Mirror, Concave.....SE-7573

Optical Fiber Model

SE-7201

This bent acrylic rod simulates the operation of optical fibers. The laser beam undergoes repeated total internal reflections and is emitted at the other face of the rod as a divergent beam.



Specifications:

Dimensions: 50 cm length and 1.0 cm diameter, with two windings of approx. 5 cm diameter.

Order Information

Optical Fiber Model..... SE-7201
Required:
Red Diode Laser Pointer..... SE-9716C p. 317

Spectrometer

Wireless Spectrometer (Vis)

PS-2600A

For iOS, Android™, Computers, and Chromebooks™

Now includes Spectrometry 2.0 functionality!

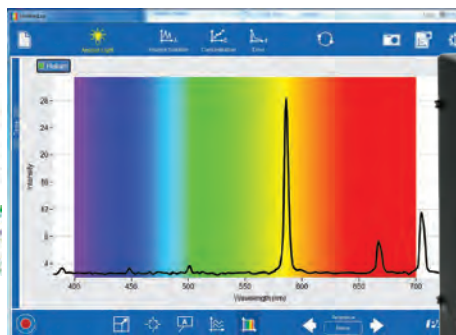
- ▶ Measures intensity, absorbance, transmittance, and fluorescence.
- ▶ Works on all computing platforms
- ▶ Bluetooth® or USB connectivity
- ▶ Includes free award-winning Spectrometry software



//CODiE//
2017 SRA CODE WINNER

bett
AWARDS 2017
FINALIST

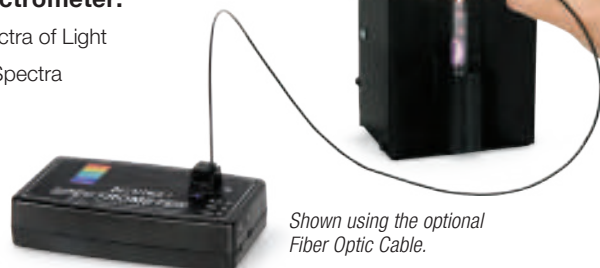
2016 AWARDS
EXCELLENCE
TECH LEARNING



Helium spectrum

Perform these labs with the Wireless Spectrometer:

- ▶ Emission Spectra of Light
- ▶ Absorbance Spectra
- ▶ Beer's Law
- ▶ Kinetics
- ▶ Fluorescence



Shown using the optional Fiber Optic Cable.

Specifications:

Resolution: 2–3 nm FWHM

Detection Range: 390–950 nm

Fluorescence Excitation Wavelengths: 405 nm and 500 nm

Light Source: LED-boosted tungsten

Connectivity: Bluetooth 5.2

Fiber Optic Cable

PS-2601

This 1m Fiber Optic Cable extends the Wireless Spectrometer's capabilities beyond simple cuvette investigations. The cable is transparent to support the entire range reported by the Wireless Spectrometer PS-2600.



Order Information

Fiber Optic CablePS-2601

Includes:

- Cuvettes (10)
- Spectrometry Software



Order Information

Wireless Spectrometer (Vis)PS-2600A

UV-Vis Spectrometer

SE-3607

- ▶ Uses PASCO's award-winning Spectrometry software
- ▶ Intuitive calibrations
- ▶ Spectral scans from 180 to 1050 nm

The SE-3607 is an easy-to-use, wide range UV-Vis spectrometer that delivers fast, accurate and reliable performance for routine analyses in college and university teaching labs. With USB connectivity and cross-platform Spectrometry Software, the PASCO UV-Vis Spectrometer improves collaboration between lab members, enabling data collected on a computer or laptop to be analyzed on tablets, iPads, and Chromebooks*.

* Chromebooks are not compatible with the PASCO UV-Vis Spectrometer for data collection (analysis only).



Includes:

- Semi-Micro Volume Cuvettes (Qty. 10)
- Cuvette Rack (EC-3590)
- USB-A to USB-B Cable
- External AC Adapter, 24 V Power Supply
- Foam Lined Carrying Case (ABS)



Order Information

UV-Vis SpectrometerSE-3607

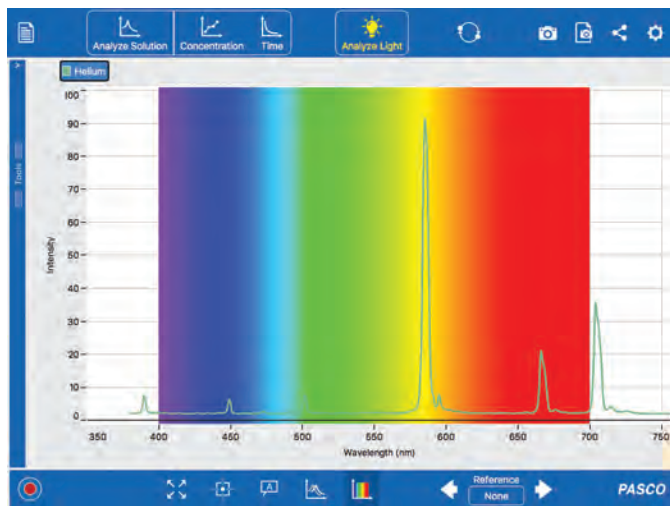
PASCO's FREE Spectrometry Software Puts Learning First

PASCO's award-winning software for iOS, Android™, Computers, and Chromebooks*

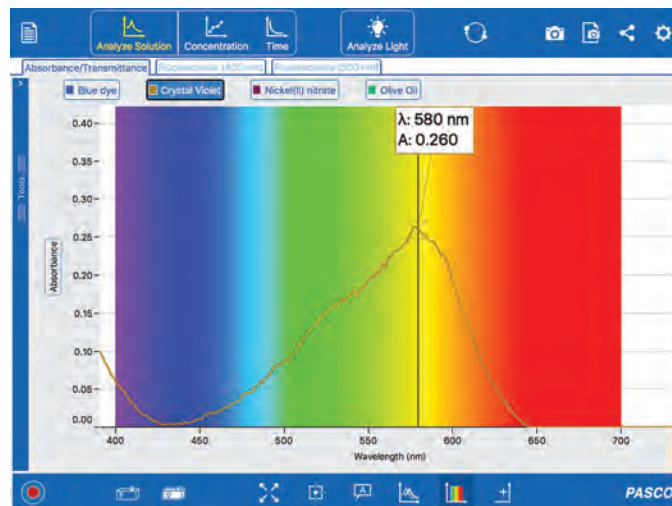
- Designed by teachers
- Specialized software specifically targets spectrometry activities
- Program guides students through the four common types of spectrometer uses
- Calibration routine is made clear and intuitive

The four specially targeted activities are:

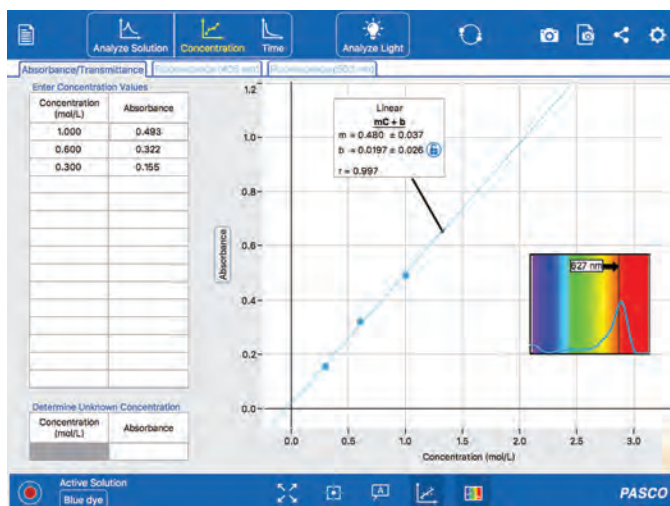
1. Analyze light sources with the optional Fiber Optic Cable.
2. Analyze the absorbance, transmittance, and fluorescence of colored solutions.
3. After the analysis wavelength is set, you can easily create calibration curves and determine the unknown concentration (Beer's Law).
4. Observe the kinetics of a reaction involving a colored solution. Easily create the required graphs ($\ln(x)$, $1/x$) to determine the order of the reactants.



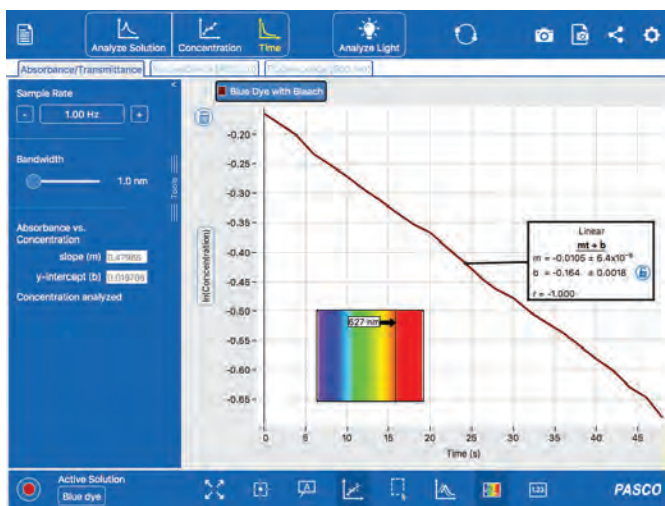
Analyze light sources with the optional Fiber Optic Cable.



Visualize the absorbance of visible wavelengths with corresponding colors (optional).



Create Beer's Law plots to relate absorbance and concentration.



Quickly plot calculations of Concentration vs. Time to determine the order of a reaction.

The Wireless Spectrometer comes with **PASCO's FREE** award-winning Spectrometry software.

- Free software for iOS, Android™, Mac® and Windows®.
- Will run on Chromebooks™ with Google Play store.
- Designed specifically for student spectrometry experiments.

Download at pasco.com/downloads

*Our list of compatible Chromebooks is expanding rapidly. Check pasco.com/spectrometer for the latest updates.

Spectrophotometer

Educational Spectrophotometer System

OS-8450 (PASPORT)

OS-8539 (ScienceWorkshop)

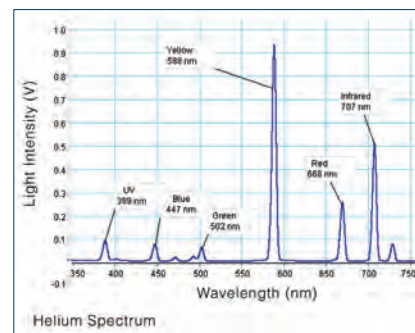
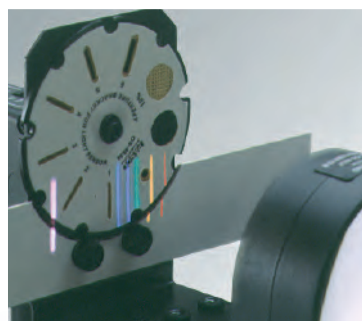
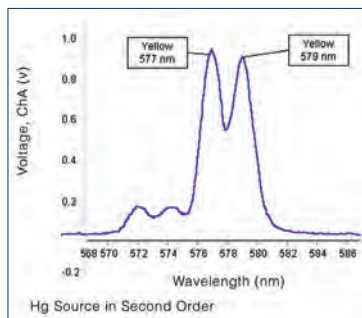
Educational Spectrophotometer Accessory Kit

OS-8537

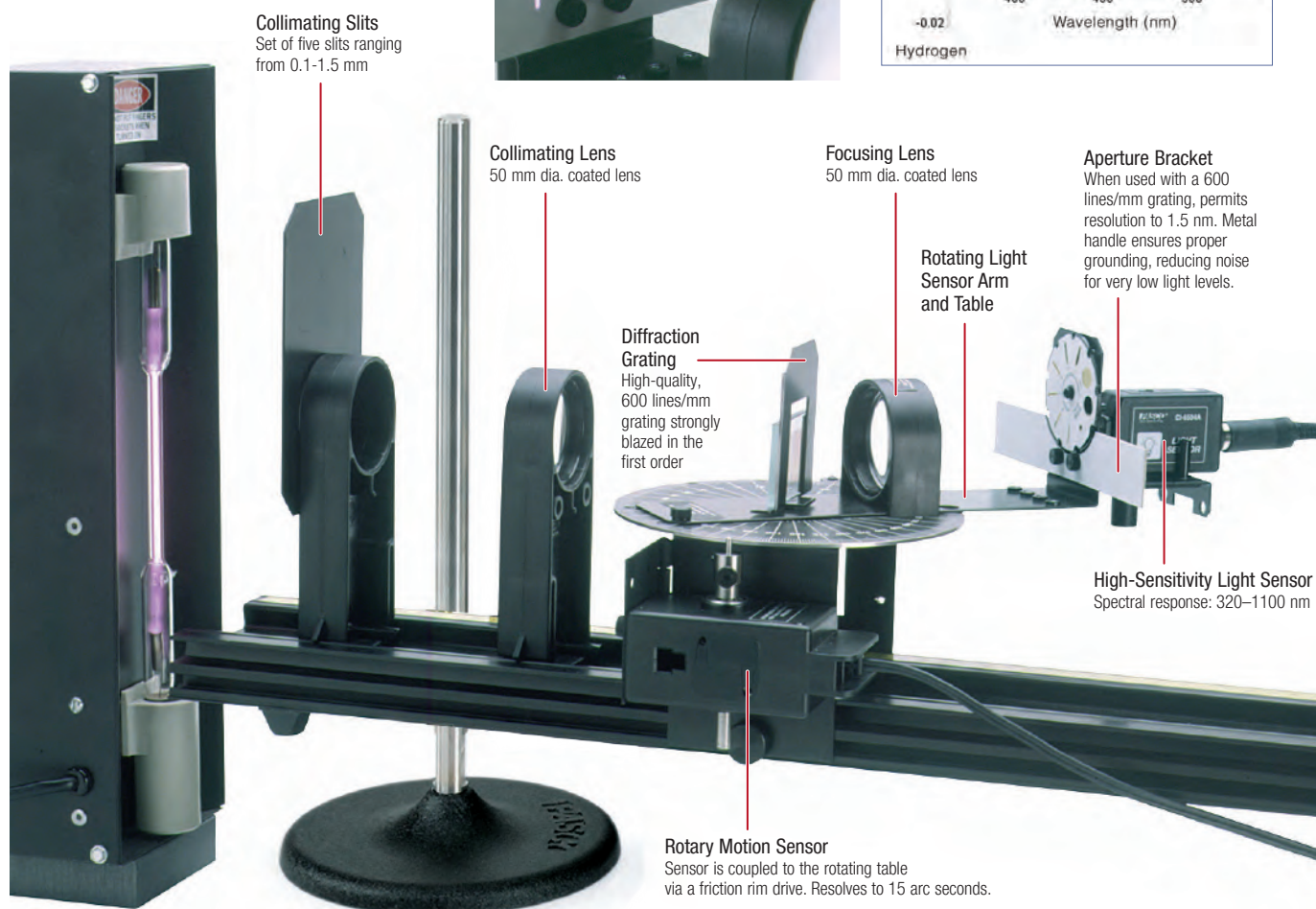
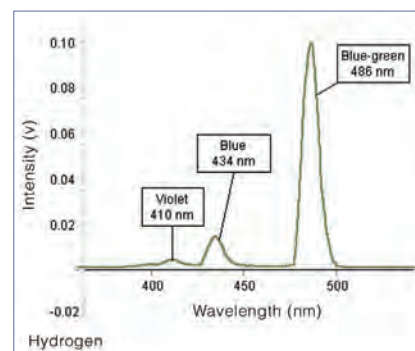
- Analyze and graph spectral lines
- Explore relationships between angle, wavelength, and intensity
- Versatile and inexpensive

PASCO's Educational Spectrophotometer teaches basic optical principles and allows quantitative measurements rivaling those of more expensive units.

When the Spectrophotometer is used with PASCO's Capstone software, 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.



Typical Spectrum Graphs



Educational Spectrophotometer Components

Teachers who already own a PASCO Interface and the Basic Optics System OS-8515C should purchase the Accessory Kit OS-8537 and any additional equipment needed from the list below.

The Spectrophotometer System includes:

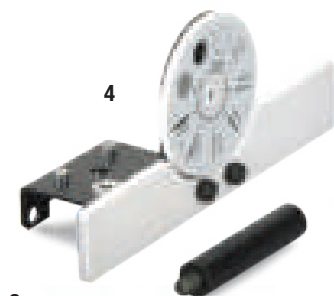
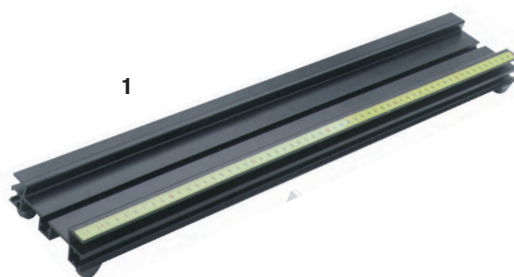
1. Optics Bench (60 cm) OS-8541
2. Rotary Motion Sensor
3. High-Sensitivity Light Sensor
4. Aperture Bracket OS-8534A
5. Spectrophotometer Table
6. Rotating Arm
7. Collimating Slits and Lens
8. Focusing Lens
9. Diffraction Grating and Holder
10. Optics Bench Rod Clamps (2) ME-9836

ScienceWorkshop
OS-8539

CI-6538
CI-6604

PASPORT
OS-8450

PS-2120A
PS-2176



The Spectrophotometer Accessory Kit (OS-8537) includes:

5. Spectrophotometer Table
6. Rotating Arm
7. Collimating Slits and Lens
8. Focusing Lens
9. Diffraction Grating and Holder
10. Optics Bench Rod Clamps (2) ME-9836

Note: The open design of this spectrophotometer accessory is ideal for education. It is not intended for industrial or research applications.

High-Quality Gratings 600 lines per mm

SE-9358

The 600 lines/mm grating is strongly blazed in the first order. It has excellent resolving power and produces bright, sharp spectral lines for spectrometer labs or for projecting spectra in lecture demonstrations.



Order Information

High-Quality Gratings 600 lines per mm..... SE-9358

Order Information

PASPORT Educational Spectrophotometer..... OS-8450
Educational Spectrophotometer System..... OS-8539
Educational Spectrophotometer Accessory Kit..... OS-8537

For use with PASPORT Sensors, see the Atomic Spectra experiment EX-5546B on page 404.

For adjusting height of optics bench to your light source:

Round Base with Rod..... ME-8270 p. 205

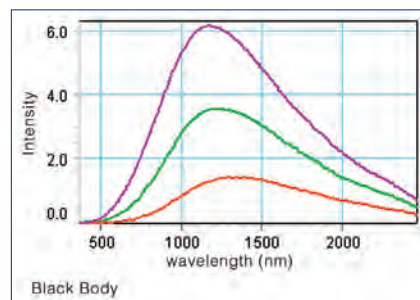
Spectrophotometers

Prism Spectrophotometer Kit – Blackbody Experiment

OS-8544

- ▶ High-quality prism
- ▶ Blackbody light source

Add this kit to the Educational Spectrophotometer System (pages 328-329) to plot blackbody curves. A prism is used to disperse the light (instead of a diffraction grating) so the infrared doesn't overlap the second order visible spectrum.



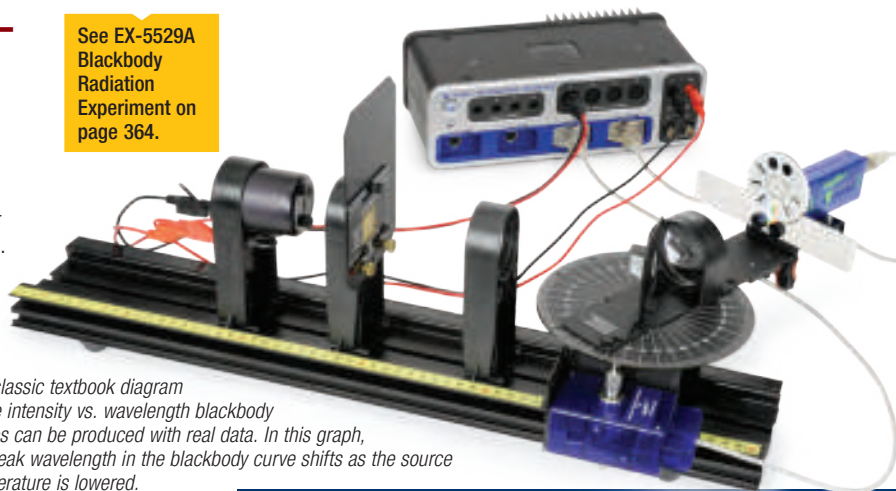
The classic textbook diagram of the intensity vs. wavelength blackbody curves can be produced with real data. In this graph, the peak wavelength in the blackbody curve shifts as the source temperature is lowered.

Includes:

- Mounted Prism
- IR Filter
- Blackbody Light Source



See EX-5529A
Blackbody
Radiation
Experiment on
page 364.



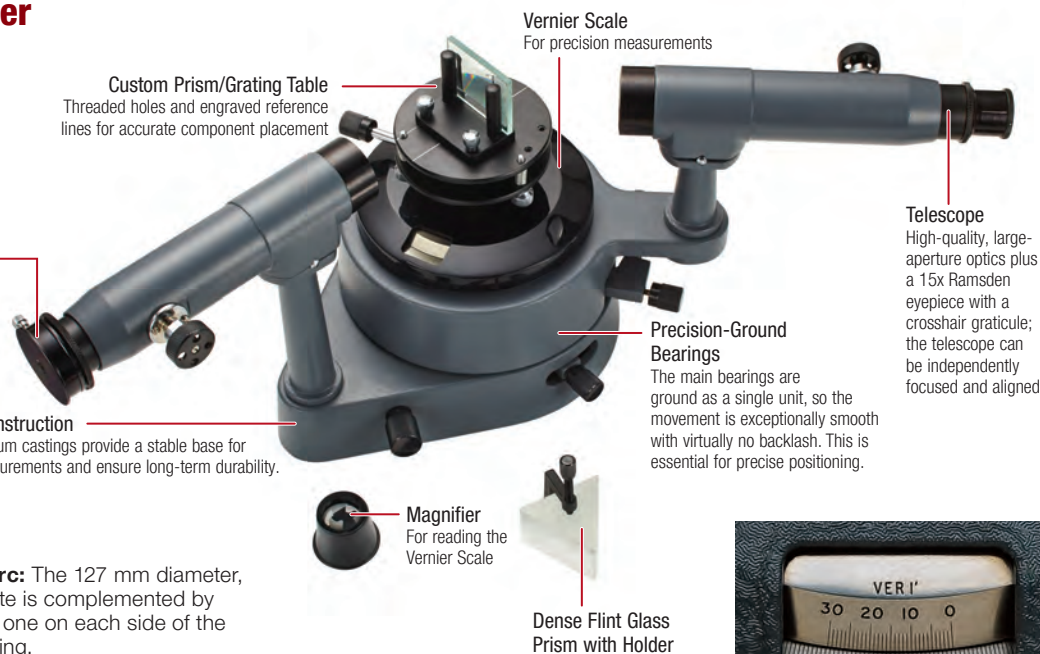
Order Information

Prism Spectrophotometer Kit – Blackbody Experiment	OS-8544	
Required for experiment:		
PASPORT Broad Spectrum Light Sensor	PS-2150	p. 42
PASPORT Educational Spectrophotometer	OS-8450	
850 Universal Interface	UI-5000	p. 20
PASCO Capstone		pp. 8-11
Replacement Supplies:		
Replacement Light Bulbs (10)	SE-8509	
OR components of the system may be ordered separately:		
Black Body Light Source	OS-8542	
Prism Mount	OS-8543	

Student Spectrometer

SP-9268A

- ▶ Wide aperture optics
- ▶ Precision vernier: resolves one minute of arc
- ▶ Durable and precise



Collimator
High-quality, large-aperture optics with a 6 mm long slit of adjustable width; the collimator can be independently focused, leveled, and aligned.

Durable Construction
Heavy aluminum castings provide a stable base for delicate measurements and ensure long-term durability.

Custom Prism/Grating Table
Threaded holes and engraved reference lines for accurate component placement

Vernier Scale
For precision measurements

Precision-Ground Bearings
The main bearings are ground as a single unit, so the movement is exceptionally smooth with virtually no backlash. This is essential for precise positioning.

Telescope
High-quality, large-aperture optics plus a 15x Ramsden eyepiece with a crosshair graticule; the telescope can be independently focused and aligned.

Magnifier
For reading the Vernier Scale

Dense Flint Glass Prism with Holder

The Vernier Scale resolves angle measurements within 1 minute of arc.



Features:

- ▶ **Resolution to 1 Minute of Arc:** The 127 mm diameter, precision-engraved degree plate is complemented by 2 precision-engraved verniers, one on each side of the instrument for convenient reading.
- ▶ **Wider Aperture Optics:** 32 mm wide apertures on the telescope and collimator provide more light for brighter and sharper images.
- ▶ **Rack and Pinion Focusing:** On both the telescope and the collimator. Focusing is easier and more precise.
- ▶ **Rotatable Table:** For greater flexibility in measurements. Turn the table by hand for coarse adjustments. Use the fine lead screw for delicate adjustments.

Order Information

Student Spectrometer	SP-9268A	
Recommended:		
Spectral Light Sources		p. 316

UV Beads (1000)

SE-7729



Shining an ultraviolet flashlight on UV-sensitive beads causes them to change color.

UV-sensitive beads are white when indoors but change color instantly when exposed to UV radiation. These beads make students aware of UV radiation. Students can explore how much UV there is on a cloudy day and how much UV is blocked by car windows.

Each bead is created with a pigment that changes color as the ultraviolet energy is absorbed. When the UV radiation is removed, the beads will return to their pale white color. This process can be repeated many thousands of times. Each package includes 1000 beads.

Order Information

UV Beads (1000).....SE-7729

UV Flashlight

SE-7730



This ultraviolet flashlight with 51 UV LEDs is great for illuminating UV beads and activating fluorescent materials. The wavelength is centered on 385 nm. Powered by three AA batteries (not included).

Specifications:

Wavelength: 385 nm

Body Material: Machined aluminum with rubber O-rings

Length: 14 cm

Bulb Type: 51x UV LED

Bulb Life: 50,000 hours

Battery Type: 3 AA (not included)

Battery Life: Approx. 20 hrs on new batteries

Order Information

UV Flashlight.....SE-7730

Spectral Light Sources

Mercury Light Source

SE-6608

This bright Mercury Light Source is perfect for studying spectra with the Educational Spectrophotometer (OS-8539). It is also used with the Photoelectric Effect experiment (SE-6609 and EX-5549A) and mounts on the extruded track in that experiment.



Includes:

- Mercury Light Source Housing
- Power Supply
- Replacement Hg Bulb: SE-6597

Order Information

Mercury Light SourceSE-6608

Replacement Supplies:

Replacement Hg BulbSE-6597

Spectroscope

SE-8688

The rugged, stainless steel design of this spectroscope means durability. Turn the dial to adjust the slit width and slide the eyepiece back and forth to focus the spectrum.



Order Information

Spectroscope.....SE-8688

Quantitative Spectroscope

SE-8819

This high-quality quantitative spectroscope is used for observing and measuring emission spectra from light sources. It is thoughtfully designed to hold the diffraction grating and scale securely for legible readings. The scale allows you to measure wavelengths from 400 to 700 nm. The spectroscope is versatile for measuring spectra emitted from a charged gas tube, flame test, or basic astronomy applications.



Specifications:

Measurement range: 400 - 700 nm

Measurement accuracy: 5 nm

Diffraction grating: 500 lines/mm

Order Information

Quantitative SpectroscopeSE-8819

Light Sources

Diffraction Grating Set (10 pack)

OS-8443

NEW

This set of 10 diffraction gratings are mounted on stiff cardboard and have printed sample spectra. This allows students to identify the gas in a spectral tube by comparing the spectral lines they see through the grating to the printed spectral chart. The printed spectra include hydrogen, helium, mercury, sodium, and neon.

The cards are easy to hold and the printing encourages students to orient the grating in the proper direction to see the spectrum (unlike the traditional square slide).

The gratings have 1000 lines/mm.



Specifications:

Grating Resolution: 1000 lines/mm

Grating Dimensions: 5 cm wide, 3.8 cm high

Card Dimensions: 7 cm wide, 12.4 cm high,
0.6 mm thick

Printed Spectra: H, He, Hg, Na, Ne



Includes:

- Diffraction Cards (10)

Order Information

Diffraction Grating Set (10 pack) OS-8443

Spectral Tube Power Supply and Mount

SE-9460

This system is easy-to-use and inexpensive, with a variety of safety features that make it suitable for beginning labs. Mount any of the eight different spectral tubes into the Power Supply and turn it on. The 26 cm long tubes are capillary-thin over the middle 10 cm, providing sharp, bright spectra.



Features:

► **Student Safety:** The tubes mount from the front of the supply and snap into molded sockets that fully enclose the conductive ends. The all-metal case is electrically grounded.

► **Spectral Tube Safety:** A current limiting transformer protects the tubes.

A protective shield also helps safeguard the tubes, while blocking unwanted ambient light for clear viewing. The glass does not transmit UV light.

► **Power Requirements:**

115 OR 220 VAC, 50/60 Hz.

► Emission tubes sold separately.

Order Information

Spectral Tube Power Supply
and Mount SE-9460

Spectral Tubes

- Argon
- Carbon Dioxide
- Helium
- Hydrogen
- Krypton
- Mercury
- Neon
- Water Vapor



These spectral tubes are designed for use in the Spectral Tube Power Supply and Mount (at left).

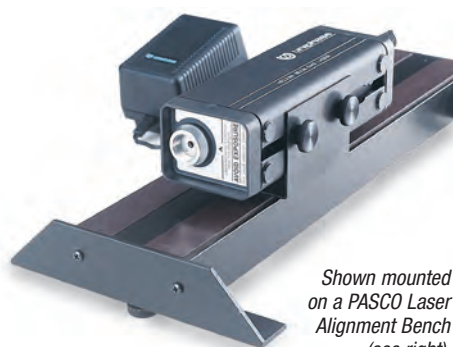
Order Information

Spectral Tubes:

Argon.....SE-9463
Carbon DioxideSE-9464
Helium.....SE-9462
Hydrogen.....SE-9461
Krypton.....SE-9465
Mercury.....SE-9466
Neon.....SE-9467
Water Vapor.....SE-9468

Mini Laser with Bracket

OS-8514



*Shown mounted
on a PASCO Laser
Alignment Bench
(see right).*

CLASS II LASER PRODUCT
LASER RADIATION – DO NOT STARE INTO BEAM OR VIEW
DIRECTLY WITH OPTICAL INSTRUMENTS

This 0.5 mW Helium Neon Laser is ideal for use with the PASCO Advanced Optics System. It includes a mounting bracket that attaches to the PASCO Magnetic Optics Bench and permits adjustment of the laser beam in the x and y axes.

The aperture has a 15.8 mm (5/8") receptacle for mounting beam spreaders or spatial filters. An AC adapter is included, but the unit can be powered with any power source providing 0.7 A at 12 VDC.

Specifications:

Output: 0.5 mW min

Wavelength: 632.8 nm

Polarization: Random

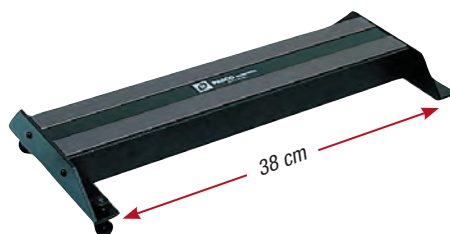
Power: 115/220 VAC, 50/60 Hz

Order Information

Mini Laser with Bracket OS-8514

Laser Alignment Bench

OS-9172



This Laser Alignment Bench connects to the Optics Bench with the included couplers, which leaves the full 1 m length of the Optics Bench free for experimental work.

Order Information

Laser Alignment Bench OS-9172

Laser Pointers

SE-9716C (Red)

SE-8805A (Green)

- ▶ Push-button switch
- ▶ Inexpensive



CLASS II LASER PRODUCT
LASER RADIATION – AVOID DIRECT EYE EXPOSURE

Specifications:

Source: Laser diode

Wavelength: 650 nm (red pointer)
532 nm (green pointer)

Power: <1 mW max. (class II)

Battery Type: Alkaline AAA (2 included)

Dimensions: 143 mm x 12.7 mm
(red pointer); 151 mm x 13.5 mm
(green pointer)

Order Information

Red Diode Laser Pointer SE-9716C
Laser Pointer, Green SE-8805A

X-Y Adjustable Diode Laser

OS-8526A



This versatile, inexpensive diode laser is designed to mount on a rod stand. The laser can be rotated through 360 degrees. There are x- and y-adjustment screws to align the laser beam. Easy set-up makes it perfect for refraction investigations and tracking the oscillation of the Cavendish Gravitational Balance (AP-8215B).



Two knobs allow independent adjustment of horizontal and vertical alignment of the laser beam.

Specifications:

Output Power: <1 mW

Wavelength: 650 nm

Power Supply: 9 VDC, 500 mA adapter
(included)

Order Information

X-Y Adjustable
Diode Laser OS-8526A

Light Sensors

Wireless Light and Color Sensor

PS-3248

- Four sensors in one
- Ambient lux
- Irradiance
- Photosynthetically active radiation
- Detect RGB colors separately
- Bluetooth 5.2 wireless



The Wireless Light and Color Sensor features two separate apertures: One measures ambient light from the side of the box, and the other measures percent color of directional light at the end of the box.



Applications:

- Studying solar energy
- Reflection, absorption, and transmission of light through clear, opaque, and variously colored translucent mediums.
- Investigating polarization and reflectivity
- Modeling planetary motion
- Verifying the inverse square law
- Investigating insolation (solar radiation) and seasons
- Indirect PAR measurements for biological studies

PASCO's Wireless Light Sensor provides students with the tools to explore the electromagnetic spectrum, model planetary motion, and relate photosynthesis to light color and intensity.



Spot Sensor for color comparative analysis
Ambient for light properties and UV index

Specifications:

Spectral Response: 340 nm to 1150 nm

Illuminance Range: 0 to 131,000 lux

Irradiance Range: 0 to 1362 W/m²

PAR Range: 1 to 2400 $\mu\text{mol}/\text{m}^2/\text{s}$

UV Index Range: 0 to 12 (typical in daylight)

RGB Range: 0 to 100% of combined colored light

Maximum Sample Rate: 2 Hz (ambient); 20 Hz (spot)

Connectivity: USB and Bluetooth 5.2

Logging: Yes

Battery Type: Coin Cell



Recent eclipse light variation

Order Information

Wireless Light and Color Sensor.....PS-3248

PASPORT Broad Spectrum Light Sensor

PS-2150

- For use with Spectrophotometer
- Ideal for Black Body Spectrum

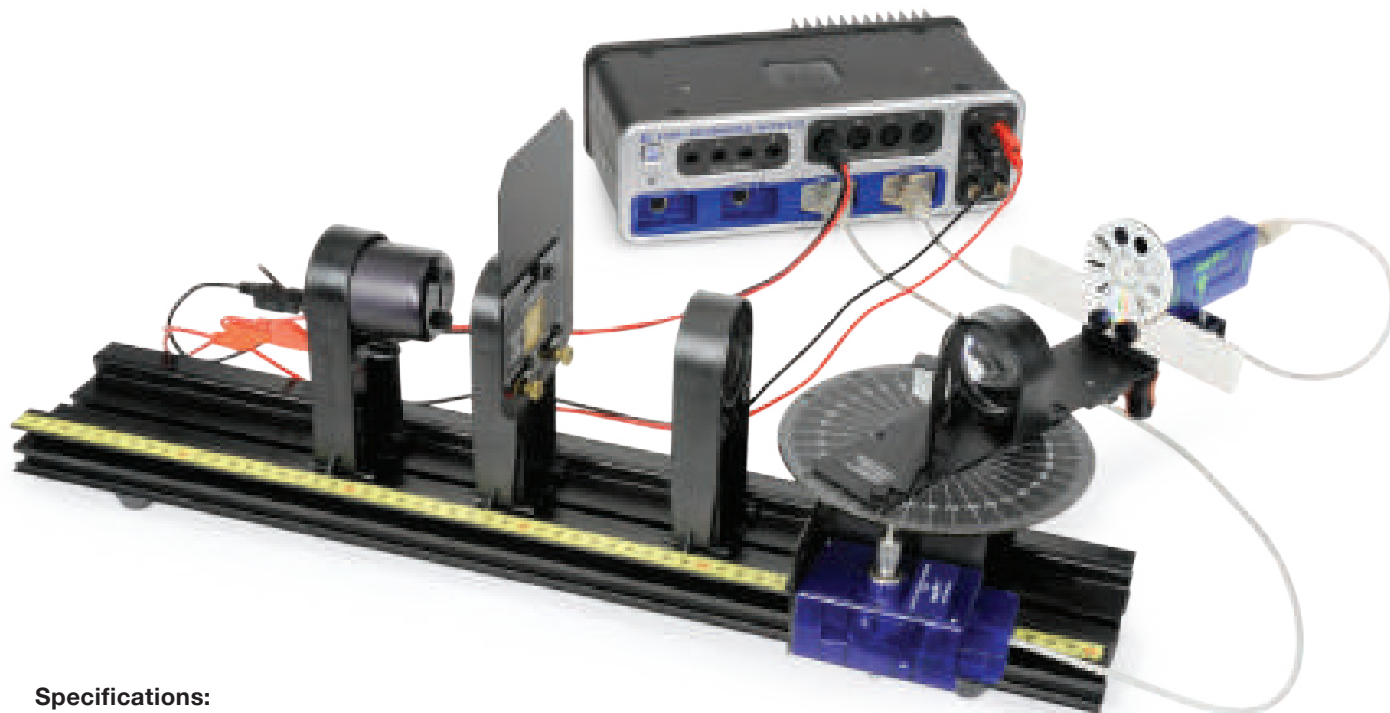
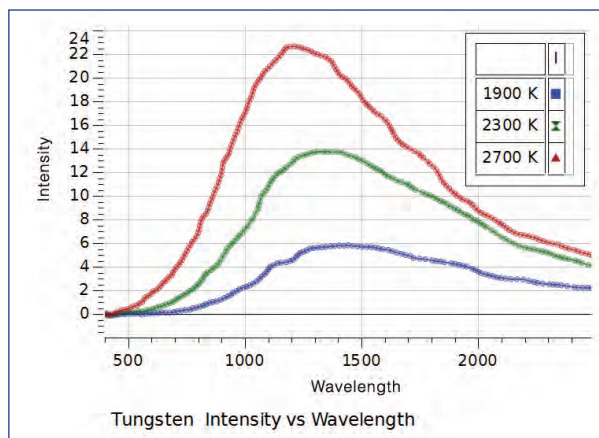


The Broad Spectrum Light Sensor is designed specifically for use with our Educational Spectrophotometer System OS-8539 and Prism Spectrophotometer Accessory OS-8543 for Blackbody experiments. The Broad Spectrum Light Sensor uses a thermopile and window combination that respond to both the near infrared and visible light necessary for the Black Body experiment.

Applications:

- Blackbody Experiment

The classic textbook diagram of the Intensity versus Wavelength blackbody curves can be produced with real data. In this graph, the peak wavelength in the blackbody curve shifts as the source temperature is lowered.



Specifications:

Sensing Element: BaF₂ window, xenon gas-filled thermopile

Spectral Response: 300 to 10,000 nm

Maximum Sample Rate: 100 Hz

Order Information

PASPORT Broad Spectrum Light SensorPS-2150

Interferometry

Introductory Michelson Interferometer

OS-8501

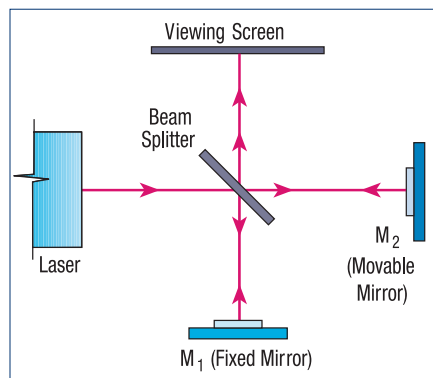
- ▶ Micrometer-controlled mirror movement
- ▶ Precision, front-surface optics
- ▶ Good quality, low price

This interferometer is a precision instrument for the introductory lab. It's easier to use, more compact, and less expensive than PASCO's Advanced Interferometer (see page 321).

It's capable of measuring the wavelength of monochromatic light with an accuracy of better than 5%. The Michelson Interferometer can also be used for making precise measurements of the index of refraction of air.

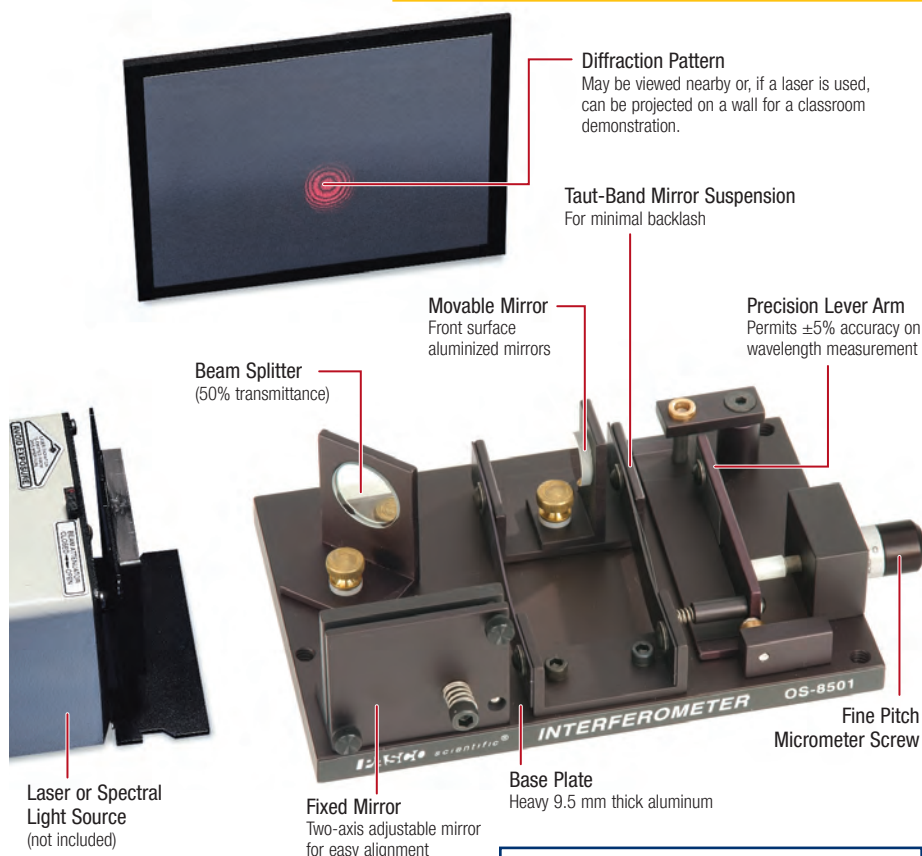
Features:

- ▶ **Smooth Mirror Movement:** Uses a taut-band mirror movement similar to PASCO's more advanced interferometer, providing smooth movement with minimal backlash.
- ▶ **Built-in Micrometer:** Measures mirror movement to a fraction of a micron.
- ▶ **Easy Setup:** Especially easy with a laser and a PASCO Optics Bench. If a laser is unavailable, a spectral light source can be used.
- ▶ **Complete Manual:** Manual includes illustrated setup instructions, a detailed discussion of basic Michelson interferometry plus two copy-ready experiments (measure the wavelength of monochromatic light and measure the index of refraction of air).
- ▶ The Introductory Michelson Interferometer provides precision interferometry at an economical price (laser and screen not included). Manual included.



Beam-splitting schematic for a basic Michelson Interferometer

The Introductory Michelson Interferometer provides precision interferometry at an economical price (laser and screen not included).



Optics Bench

Note: While the interferometer is designed to be used with the Optics Bench of the Advanced Optics System OS-9103, it can also be used without the PASCO Optics Bench.

Includes:

- Michelson Interferometer
- Gas Cell
- Collimating Lens (18.4 mm focal length)
- Lens Holder
- Storage Case
- Manual



Order Information

Introductory Michelson Interferometer..... OS-8501
Recommended:
Mini Laser with Bracket..... OS-8514 p. 317
Hand Operated Vacuum Pump OS-8502

Hand Operated Vacuum Pump

OS-8502

This Hand-Operated Vacuum Pump with Gauge is required to measure the index of refraction of air using the Introductory Michelson Interferometer.



Order Information

Hand Operated Vacuum Pump OS-8502

Complete Interferometer System

OS-9258B

- ▶ Three modes: Michelson, Fabry-Perot, Twyman-Green
- ▶ Large precision optics
- ▶ 5 kg machined aluminum base

No study of interferometry should overlook the historical importance of the Michelson interferometer. Yet in the laboratory, the Fabry-Perot and Twyman-Green interferometers can be more important tools: the first for high-resolution spectroscopy; the second for testing and producing optical components with aberrations that can be measured in fractions of a wavelength.

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

The PASCO Interferometer can be ordered in a variety of systems. The Precision Interferometer can be operated in either the Michelson or Fabry-Perot modes. The Complete Interferometer Systems also contain components for the Twyman-Green mode and a vacuum pump for the refractive index of air experiment. The Systems Component List shows the contents of each system.

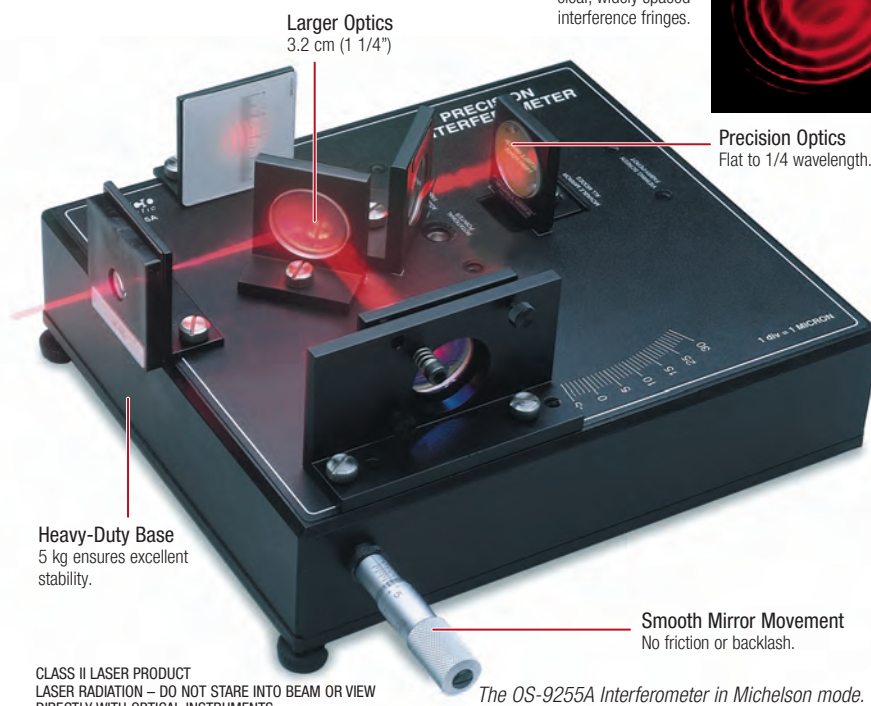
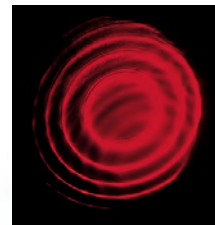
Features:

- ▶ **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 (1-1/4") 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.

Order Information

Complete Interferometer System OS-9258B
Precision Interferometer OS-9255A
Interferometer Accessories Kit OS-9256A

Fabry-Perot Interferometry:
Two parallel, partially reflecting mirrors create clear, widely spaced interference fringes.



CLASS II LASER PRODUCT
LASER RADIATION – DO NOT STARE INTO BEAM OR VIEW
DIRECTLY WITH OPTICAL INSTRUMENTS

The OS-9255A Interferometer in Michelson mode.

Add the Accessories Kit (OS-9256A)

(included in the Complete Interferometer System) to:

- ▶ Demonstrate that cross-polarized beams will not interfere
- ▶ Measure lens irregularities in Twyman-Green Mode

- ▶ Measure the indices of refraction for air and glass. The indices of refraction for user-supplied materials can also be measured.

Note: The fitted case will hold all components and accessories except the 5 kg base, which must be stored separately.

		A	B	C
A. OS-9258B: Complete Interferometer System with Laser		B. OS-9255A: Precision Interferometer		
C. OS-9256A: Interferometer Accessories Kit				
Systems Component List		A	B	C
Machined base—5 kg		1	1	
Three-point adjustable mirror		1	1	
Mounted beam-splitter		1	1	
Mounted movable mirror		1	1	
Accessory mounts		3	2	1
Viewing Screen OS-9138		1	1	
Diffuser OS-9120		1	1	
Double Convex Lens (18 Mm) OS-9132		1	1	
Compensator lens		1	1	
Fitted case		1	1	
Vacuum Pump with Gauge OS-8502		1		1
Gas cell		1		1
Calibrated Polarizer OS-9109		2		2
Glass Plate OS-9128		1		1
Rotating component holder		1		1
Twyman-Green Lenses OS-9133, OS-9132		2		2
Mini Laser with Bracket OS-8514		1		
Laser Alignment Bench OS-9172		1		
Instruction manual		1	1	

Microwave Optics

Basic System

WA-9314C

Advanced System

WA-9316A

- ▶ Durable construction
- ▶ Parts are made of stainless steel or die-cast aluminum.

Ethafoam® Prism with Styrene Pellets
Used for refraction of microwaves.

Rotating 18 cm High Mounts
The transmitter and receiver rotate through a full 360° and minimize tabletop reflections.

Diffraction Slit Hardware

Magnetic Mounting
All components mount magnetically.

Long-Arm Goniometer
Built-in degree and millimeter scales

Gunn Diode Transmitter
A stable, low-voltage source of linearly polarized microwaves (10.5 GHz, 15 mW)

Receiver (WA-9800A) with Built-in Amplifier

The Microwave Optics Advantage

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). The receiver has a built-in amplifier, as well as a variable sensitivity scale, ensuring accurate data for even the lowest intensity measurements.

The large 3 cm wavelength makes it easy to understand and visualize electromagnetic wave interactions. The interference and diffraction slits are several centimeters wide, and the polarizers are slotted sheets of stainless steel.

The WA-9314C Basic Microwave Optics System Includes:

- Gunn Diode Transmitter with mounting stand
- Receiver with built-in amplifier and mounting stand
- Goniometer with fixed and rotatable arms and degree scale
- Fixed-arm assembly for interferometer experiments
- Component holders: two standard, one rotating
- Rotating table
- Reflectors: two full reflectors (metal), two partial reflectors (wood)
- Polarizers
- Diffraction slit hardware
- Prism (Ethafoam) with styrene pellets
- AC adapter
- Laboratory manual with 12 experiments

The WA-9316A Advanced Microwave Optics System Includes:

- Microwave Optics: Basic System: WA-9314C
- Microwave Accessory Package: WA-9315

Order Information

Microwave Optics: Basic System..... WA-9314C
Advanced Microwave Optics System..... WA-9316A
Recommended:
The microwave transmitter and receiver assemblies may be purchased separately:
Microwave Transmitter WA-9801
Microwave Receiver WA-9800A
Microwave Mounting Stand WA-9802

Microwave Detector Probe

WA-9319A

Investigate the nodes and antinodes in standing wave patterns with this microwave probe. It plugs directly into the (WA-9800A) receiver.

Not compatible with older versions of the receiver.



Order Information

Microwave Detector Probe..... WA-9319A

Microwave Accessory Package

WA-9315

(included in the WA-9316A Advanced System)

Includes a polyethylene panel for measuring Brewster's angle and a simulated crystal for Bragg diffraction experiments.

The crystal is a cubic lattice of 100 metal spheres in a 5 x 5 x 4 array, mounted in plastic foam.



Includes:

- Simulated Crystal Lattice
- Polyethylene Panel

Order Information

Microwave Accessory Package WA-9315

Franck-Hertz System

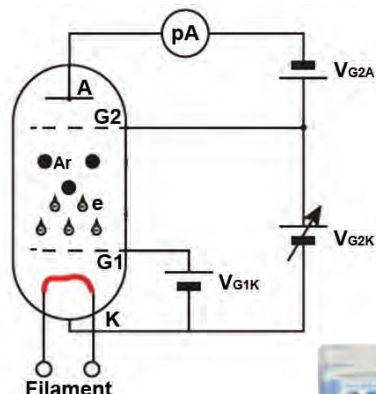
SE-9639

- Uses argon gas, so no heating is required
- Digital displays for standalone use
- Can be used with the 850 Interface and PASCO Capstone

See complete experiment on page 391.

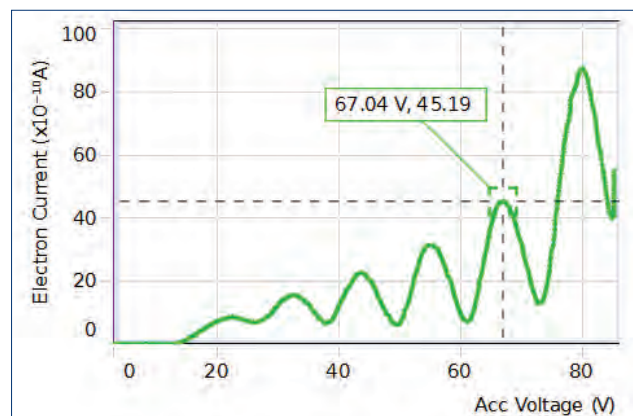
850 Universal Interface Connections for Instrument Readout

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 ($\lambda = 254$ nm) of mercury. They performed this experiment that has become one of the classic demonstrations of the quantization of atomic energy levels. They were awarded the Nobel Prize for this work in 1925.

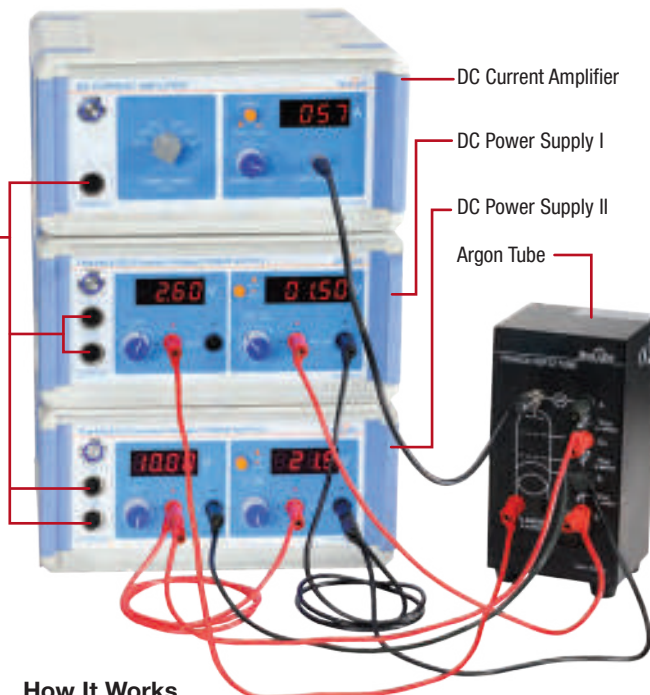


This diagram shows the internal structure of the Franck-Hertz tube and the wiring diagram.

The system can be used standalone or with the 850 Universal Interface and PASCO Capstone. The power supplies and current amplifier can be connected to the 850's analog ports to record data in Capstone.



Capstone lets students collect many more data points compared to manually taking readings from the digital readouts. The peaks and troughs are easily measured using the coordinate tool.



How It Works

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.

As the accelerating voltage is increased, the electrons undergo multiple collisions and the excitation energy of the argon atom can be determined by the differences between the accelerating voltages that cause a decrease in the current. Planck's Constant can be determined.

Specifications:

- Filling Gas:** Argon
- Filament Voltage:** ≤ 6.3 VDC
- Accelerating Voltage:** ≤ 100 VDC
- Wave Crest (or Trough) Number:** 6
- Argon Tube Life Span:** ≤ 3000 hrs

Power supply and current amplifier specs: See page 270.

Includes:

- Franck-Hertz Tube Enclosure with Argon Tube: SE-9650
- DC Power Supply I (Constant Voltage): SE-6615
- DC Power Supply II (Constant Voltage): SE-9644
- DC Current Amplifier: SE-6621
- Red and Black Patch Cords

Order Information

Franck-Hertz System SE-9639
 Power supplies and amplifier can be purchased separately. See page 270. if you already have power supplies, you will need:
 Franck-Hertz Tube Enclosure with Argon Tube SE-9650A
 Replacement Parts:
 Franck-Hertz Argon Tube SE-9645A
 Also Available:
 AR Tube Franck-Hertz Argon Tube Enclosure SE-9660

Electron Charge

Millikan Oil Drop Apparatus

AP-8210B

- ▶ Nobel Prize-quality physics in the student lab
- ▶ Ionization source for changing droplet charge
- ▶ Measures the charge of an electron to within $\pm 3\%$

The Millikan Oil Drop Experiment is one of the most popular experiments in undergraduate physics for several reasons:

- ▶ The experimental principle is straightforward and easy to understand.
- ▶ It measures a fundamental atomic constant using a method that won its originator, Robert Millikan, the Nobel Prize.
- ▶ 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 electricity.

See complete experiment on page 369.



The Millikan Oil Drop Apparatus mounted on a rod stand for easy, eye-level viewing.

Specifications:

Maximum Plate Voltage: 500 VDC

Light Source: Cool LED

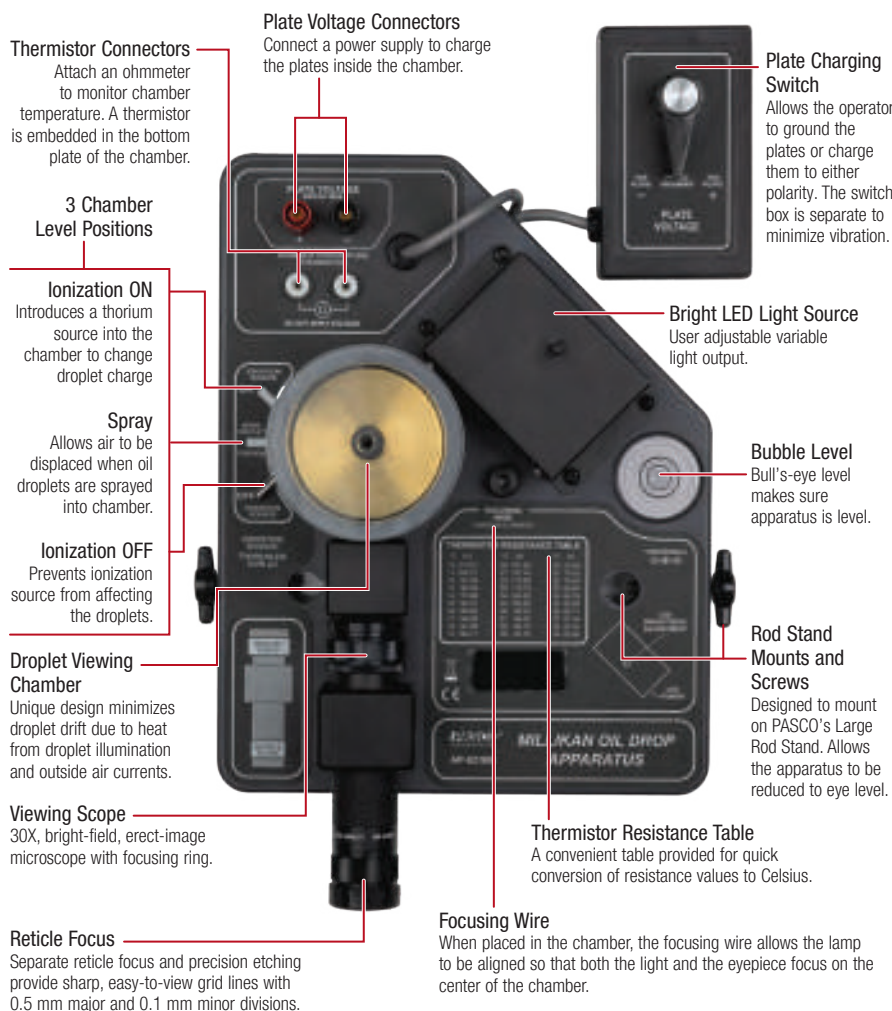
Reticle Line Separation:

0.5 mm major divisions

0.1 mm minor divisions

Plate Spacing: 7.62 mm

Plate Diameter: 60 mm



Includes:

- Millikan Oil Drop Apparatus with Switch
- Non-volatile Oil and Atomizer
- 12 VDC Lamp Power Adapter

Order Information

Millikan Oil Drop Apparatus	AP-8210B	
Required:		
Basic Digital Multimeter	SE-9786A	p. 269
High Voltage DC Power Supply	SE-9700	p. 273
Recommended for mounting unit at eye level on a standard lab table:		
Large Rod Base	ME-8735	p. 204
45 cm Stainless Steel Rod	ME-8736	p. 204
Replacement Parts:		
4 oz Bottles of Mineral Oil (Qty 4)	AP-8211	
Millikan LED Light Source	AP-8212	

Clear droplet observation and low droplet drift are essential for success with Millikan's classic experiment. PASCO's apparatus uses a pre-aligned optical system and special condenser to achieve these conditions.

Accuracy in the Oil Drop Experiment depends on the student's ability to precisely measure all the variables involved: plate voltage, plate separation, time and distance of droplet rise and fall, temperature, oil density, etc. Extreme care taken in the design and manufacturing of this unit ensures that the student's best efforts will be rewarded with more accurate results. Typically, a careful student can achieve results within 3% or less of the accepted value.

e/m Apparatus

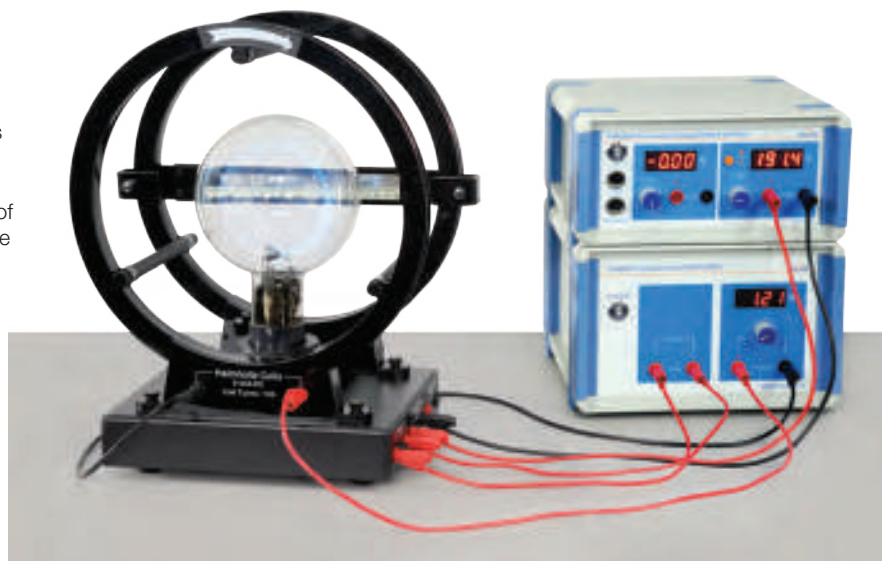
SE-9629

- ▶ Sharp, clearly visible electron beam
- ▶ Phosphorescent mirrored scale eliminates parallax errors
- ▶ Tube rotates for general study of electrons in a magnetic field

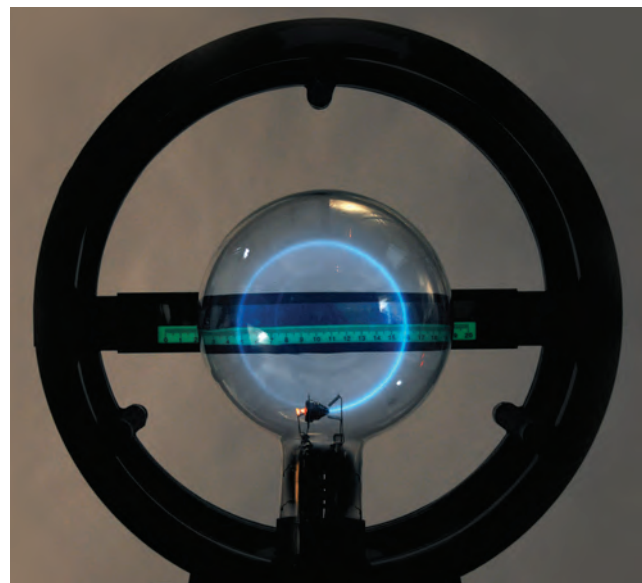
In 1897, J. J. Thomson showed that the mysterious cathode rays were actually negatively charged particles—he had discovered the electron. In the same year he measured the charge-to-mass ratio of the electron, providing the first measurement of one of the fundamental constants of the universe.

The Charge-to-Mass Ratio System reproduces one version of Thomson's landmark experiment, providing an accurate measurement of the charge-to-mass ratio of the 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.

This apparatus also has deflection plates, so students can study the effect of an electric field on moving electrons.



The complete Charge-to-Mass Ratio System includes the power supplies, which can also be used in other experiments (such as the Franck-Hertz experiment, see page 391).



Fluorescent scale shows behind the electron beam in a dark room.

Includes:

- Helmholtz Coils for e/m: SE-9626
- e/m Tube: SE-9659
- Tunable DC Power Supply (Constant Current): SE-9622
- DC Power Supply II (Constant Voltage): SE-9644
- Red and Black Patch Cords

For more information
about power supplies,
see page 270.

How It Works

A large, helium-filled electron tube is mounted between a pair of Helmholtz coils. The tube contains an electron gun, which generates a focused beam of electrons. A measured current is applied to the Helmholtz coils so that the magnitude of the magnetic field within the electron tube can be calculated. A measured accelerating potential (V) is then applied to the electron gun. The magnetic field (B) deflects the electron beam in a circular path with a radius (r) that is measured using the illuminated mm scale. From these measured values, the charge-to-mass ratio of the electron is calculated:

$$e/m = 2V/B^2r^2.$$

(The details of the calculations are fully described in the manual.)

Specifications:

Helmholtz Coil Radius: 16 cm

Number of Turns: 130

Maximum Current: 3.5 A

Filament Voltage: 6.3 VAC

Acceleration Voltage: 0–200 V

Tube Diameter: 15.5 cm

Order Information

e/m Apparatus	SE-9629
If you already have power supplies, you will need:	
Helmholtz Coils for e/m	SE-9626
e/m Tube	SE-9659

Photoelectric Effect

Photoelectric Effect System

SE-6609

- ▶ Experimentally determine Planck's Constant within 5%
- ▶ Verify that stopping potential is independent of light intensity
- ▶ Find characteristics of the material(s) inside the vacuum photodiode

The Photoelectric Effect System uses the conventional method to determine Planck's Constant within 5%. First, the metal plate in the photodiode is illuminated by various light frequencies, selected from a mercury lamp with filters. Then, the voltage is adjusted to stop the photoelectric current. The stopping voltage is then plotted against the frequency, and Planck's Constant is determined using the slope. Students can test whether the stopping voltage changes with light intensity using the various apertures and corresponding light intensities.

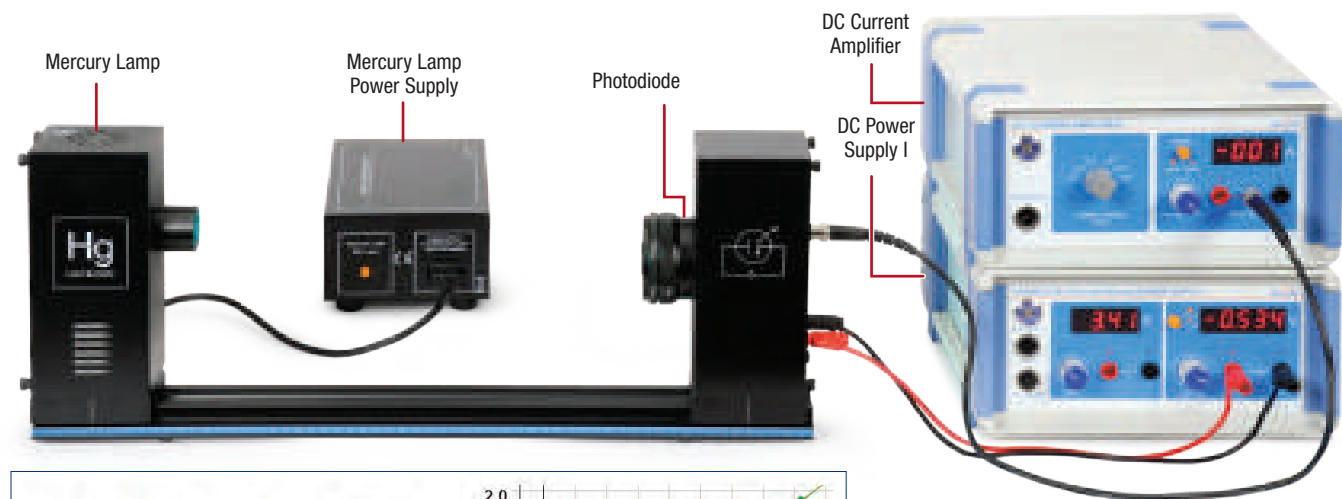
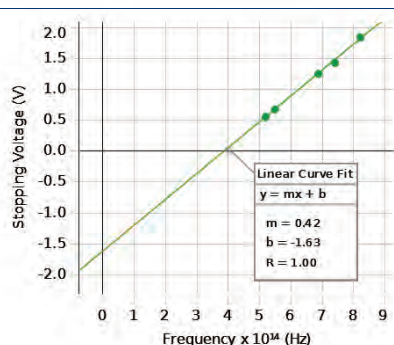


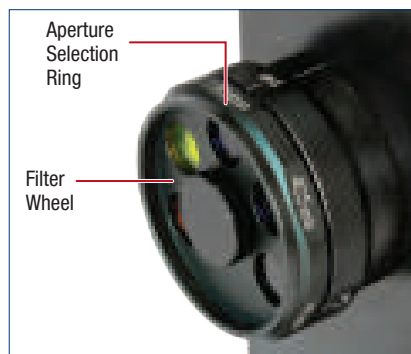
Table I: Photoelectric Effect with 4 mm Aperture

	▲ Run #1	■ Run #1
	Frequency $\times 10^{14}$ (Hz)	Stopping Voltage (V)
1	8.214	1.835
2	7.408	1.428
3	6.879	1.248
4	5.490	0.671
5	5.196	0.551



In the sample data above, the graph of Stopping Voltage vs. Frequency gives a slope of 4.2×10^{-15} V-s. This results in a value for Planck's Constant of 6.7×10^{-34} J-s, which is 1.3% above the accepted value. This graph was generated using PASCO Capstone™ software and the 850 Interface.

The filters and the apertures are built into the front of the photodiode case, making it easy to clean and eliminating the need for a separate storage box. To change the aperture size, simply pull outward on the aperture ring and rotate it to a different aperture. The filter wheel rotates independently of the aperture ring to select different frequencies of light. The wheel clicks into place, assuring that the filter is aligned with the aperture.



SE-6609 Includes:

- Basic Photoelectric Effect Apparatus: SE-6614
- DC Current Amplifier: SE-6621
- DC Power Supply I (Constant Voltage): SE-6615

SE-6614 Includes:

- Photodiode Enclosure with Tube
- Track, 60 cm and required cables
- Mercury Light Source (SE-6608)

Compatible with the 850 Interface (UI-5000, see p. 20) and PASCO Capstone

See the complete experiment on page 389.

For Power Supply and Current Amplifier specs, see page 270.

Specifications:

Current Amplifier Measuring Range:

10⁻⁸ to 10⁻¹³ A in six ranges

Photoelectric Tube Voltage Adjustment:

−4.5 V to 0 V and −4.5 V to +30 V (two ranges)

Photoelectric Tube Spectral Response

Range: 300 nm – 700 nm

Photoelectric Tube Anode: nickel ring

Five Optical Filters with Central

Wavelengths: 365.0, 404.7, 435.8, 546.1, and 578.0 nm

Order Information

Photoelectric Effect System SE-6609

If you already have the Power Supply and Amplifier, you will need:

Basic Photoelectric

Effect Apparatus SE-6614

Replacement Parts:

Photoelectric Tube

with Box Plate..... SE-6612

Share Instruments in Three Experiments and SAVE!

These three experiments require the same power supplies and amplifiers. Save storage and equip your lab for less, by sharing these instruments between all three experiments asynchronously.

1. Photoelectric Effect

Complete Setup:
Photoelectric Effect SystemSE-6609

2. Franck-Hertz

Complete Setup:
Franck-Hertz SystemSE-9639

3. Electron Charge-to-Mass Ratio (e/m)

Complete Setup:
e/m ApparatusSE-9629

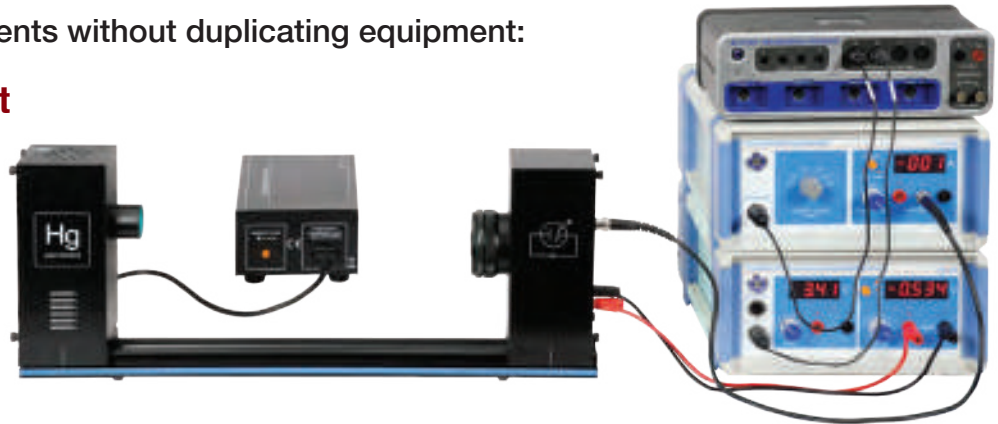
EXPERIMENT	DC Power Supply I	DC Power Supply II	DC (Constant Current) Supply	DC Current Amplifier
Photoelectric Effect	✓			✓
Franck-Hertz	✓	✓		✓
e/m		✓	✓	

Perform these experiments without duplicating equipment:

1. Photoelectric Effect

Photoelectric Effect System
SE-6609

This complete setup includes two instruments that can be used in the Franck-Hertz and e/m experiments.



2. Franck-Hertz

Add

Franck-Hertz Tube Enclosure with
Argon Tube
SE-9650A



Add

DC Power Supply II
(Constant Voltage)
SE-9644



3. Electron Charge-to-Mass Ratio (e/m)

Add

Helmholtz Coils for e/m
SE-9626



Add

Tunable DC Power Supply (Constant Current)
SE-9622



Add

e/m Tube
SE-9659



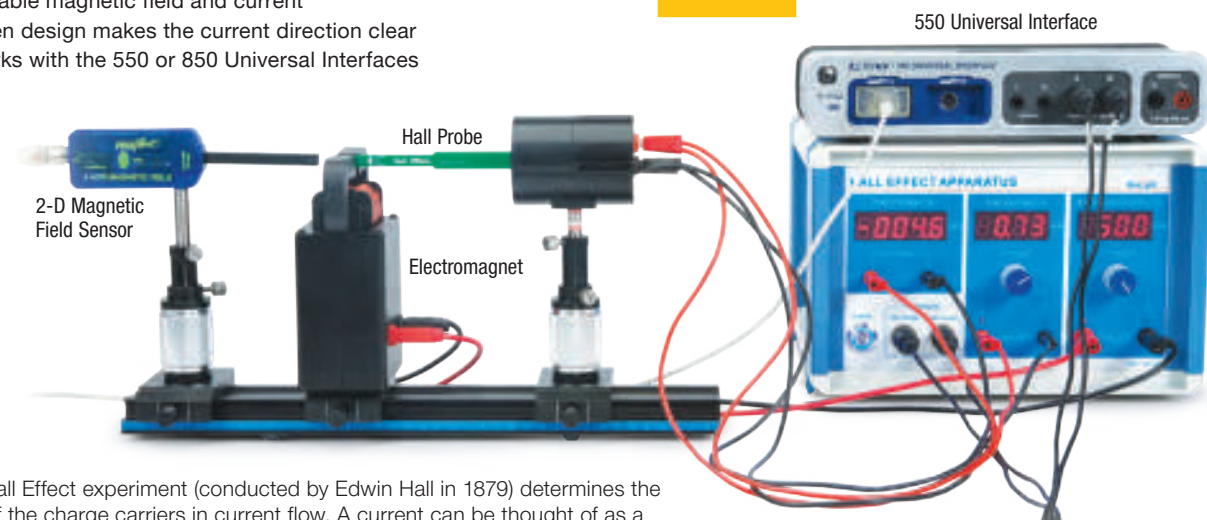
Hall Effect

Hall Effect n-Doped Semiconductor

SE-7260

See complete
experiment
on page 390.

- ▶ Variable magnetic field and current
- ▶ Open design makes the current direction clear
- ▶ Works with the 550 or 850 Universal Interfaces



The Hall Effect experiment (conducted by Edwin Hall in 1879) determines the sign of the charge carriers in current flow. A current can be thought of as a negative charge moving in one direction or as a positive charge moving in the opposite direction. To determine which it actually is, the semiconductor is immersed in the magnetic field transverse to the direction of flow of current. The moving charge experiences a force, causing a charge build-up on one side of the semiconductor (creating an electric field), which in turn leads to a force. The direction of the electric field will depend on the sign of the charge carriers, which is revealed by the polarity of the Hall voltage across the semiconductor.

The magnitude of the Hall voltage is dependent on the current, the charge carrier density, and the magnitude of the magnetic field. In modern day electronics, the Hall Effect is used to measure the magnitude and direction of magnetic fields.

PASCO Advantage

The open design of this Hall Effect apparatus makes it possible for students to see the direction of the current and the magnetic field, enabling them to use the sign of the Hall voltage to deduce the sign of the charge carriers.

Specifications:

n-Doped Semiconductor Material: GaAs

Hall Sensitivity: ≥ 150 mV/(mA-T)

Magnet Space: 10 mm

U-core Electromagnetic Coil: 1000 Turns

Magnet Field: 0 to 0.065 T (at 1A)

Excitation Current: 0 to 1 A DC

Hall Voltage: 0 to 1.9999 V

Power Supply Digital Readout for Current, Hall Voltage, and Magnet Current

Includes:

- Hall Probe Unit, n-Semiconductor (GaAs)
- Hall Effect Power Supply
- U-Core Electromagnetic Coil
- Track, Length 40 cm
- Optical Carrier (2)
- Adjustable Post Holder with 9 cm Post (2)
- Banana Cords (6)
- Connecting Cables for 550/850 Interface (2)
- Manual

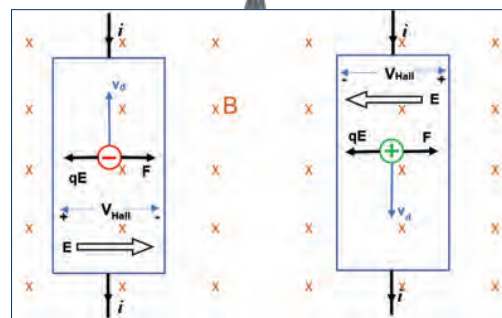


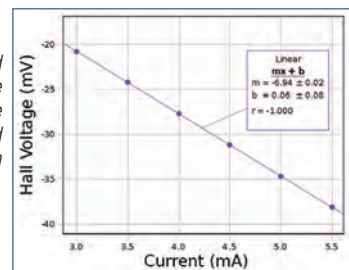
Figure 1

Figure 2



The directions of the current and the voltage probe are clearly marked on the probe that holds the semiconductor.

Using the 550 Universal Interface to record data, this plot of the Hall Voltage vs. the Current was made in PASCO Capstone software. In this case, the magnetic field was held constant and the current through the semiconductor was varied.



Order Information

Hall Effect n-doped Semiconductor SE-7260

Note: This apparatus can be used manually by reading the digital displays. Measuring the magnetic field requires a sensor or other Tesla meter. This apparatus includes connector cables for an 850 or 550 Interface so data collection can be automated.

Recommended:

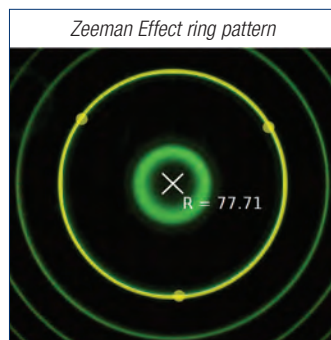
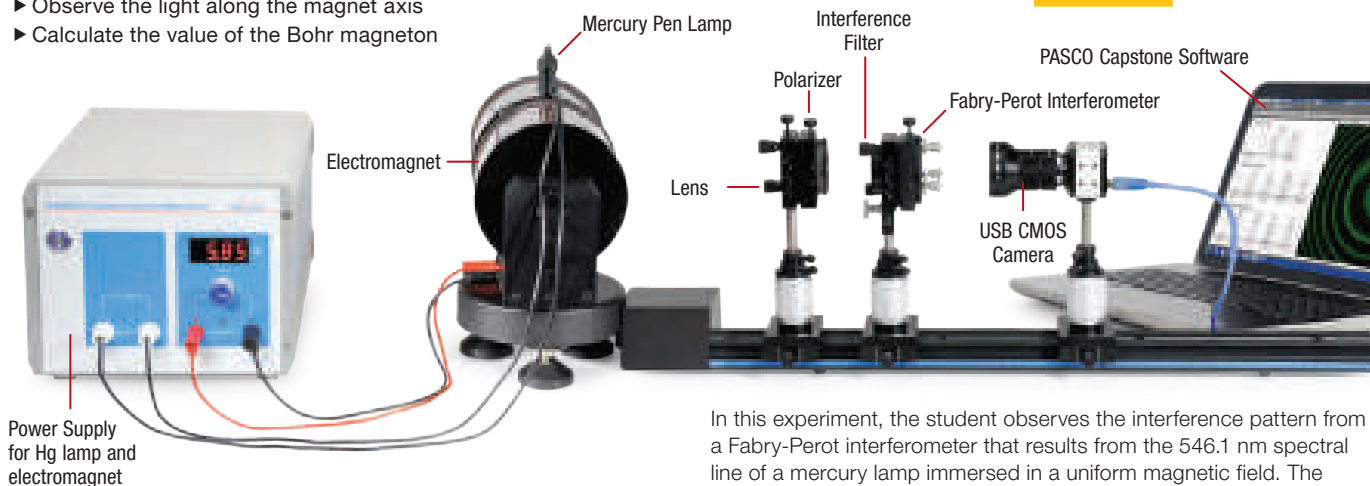
Magnetic Field Meter SE-7579B p. 268
 850 or 550 Universal Interface UI-5000 or UI-5001 pp. 20-23
 PASCO Capstone Software pp. 8-11

Zeeman Effect

SE-9654

- Measure the Zeeman Effect with polarization perpendicular and parallel to the field
- Observe the light along the magnet axis
- Calculate the value of the Bohr magneton

See complete
experiment
on page 392.



Electromagnet
produces
over one Tesla.



The vertical
position can
be adjusted
precisely
with the fine-
adjustment
mechanism.

Lens and
polarizer mount
can be adjusted
vertically and
horizontally.



The optics and track come in an
aluminum hard case with foam
cutouts for each component.

In this experiment, the student observes the interference pattern from a Fabry-Perot interferometer that results from the 546.1 nm spectral line of a mercury lamp immersed in a uniform magnetic field. The magnetic field is varied from zero to nearly 1 Tesla.

Initially, the light is viewed along an axis perpendicular to the magnetic field axis. A polarizer is used to show the three lines due to light that is polarized parallel to the field axis and to show the six lines that are polarized perpendicular to the field axis. The pattern may also be viewed along the field axis where the light is circularly polarized.

Finally, the pattern that is polarized perpendicular to the field axis is used to calculate the Bohr magneton. All atomic magnetic moments are integral or half-integral multiples of the Bohr magneton.

Specifications:

CMOS Camera and Lens: 1/3", 2M pixels, $f = 50$ mm, RA = 1:4

Fabry-Perot Interferometer: $\lambda = 546.1$ nm

Collimating Lens: $f = 125$ mm

Mercury Lamp: 10A, 3W

Electromagnet: 5A, 1.2T, ~7.4 mm gap

Tunable DC Power Supply: 110V/220V, 6A

Precision Adjustable Optical Mount: $\Phi 45$ mm, 2D

Horizontal Optical Mount: $\Phi 45$ mm, travel = 36 mm, 2D

Track Length: 600 mm

Includes:

- Electromagnet
- Optics
- Power supply
- PASCO Capstone Single User License

Order Information

Zeeman Effect SE-9654

May be purchased separately:

Electromagnet SE-9655 p. 258

Tunable DC Power Supply 6A SE-9656 p. 271

Replacement Part:

Pen-Type Mercury Lamp 10A, 3W SE-9658

Optional:

Magnetic Field Meter SE-7579B p. 268

Field strength as a function of the current supplied to the magnet is included in a chart.
To directly measure field strength, order the optional Magnetic Field Meter (SE-7579B).

Gravitational Torsion Balance

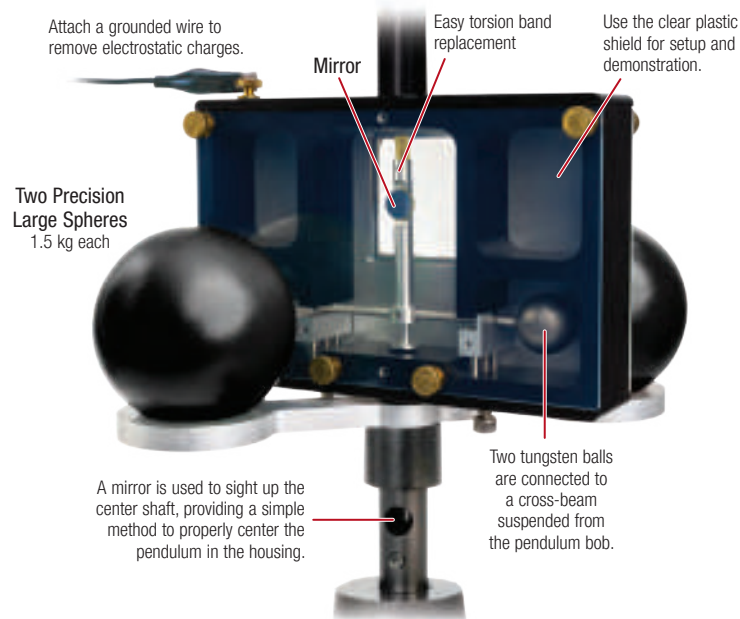
Cavendish Gravitational Torsion Balance

AP-8215B

- Measure the universal gravitational constant in a single lab period
- Adjustment and locking mechanisms decrease lab setup time
- Torsion band easily replaced

Features:

- View the pendulum bob's position through a mirror in the unit's central shaft. Use the leveling screws in the cast-iron base to accurately center the bob.
- A special "U"-shaped groove in the locking mechanism is used to damp the oscillation of the small tungsten balls.
- Easily adjust pendulum height with a single screw.
- The smooth action of the rotating large ball support ensures that the balls can be moved easily without disturbing the motion of the small tungsten balls.



Specifications:

Torsion Band: Beryllium copper ribbon, 36 cm long with a cross section of 0.0178 x 0.15 mm

Small Masses: Two tungsten balls of 38 g each

Large Masses: Two balls of 1.5 kg each

Period of Oscillation: Eight minutes (approx.)

Accuracy: 5% (approx.)

Includes:

- Torsion Balance Assembly
- Large Rod Base ME-8735
- Extra Torsion Band
- Manual

Computerized Version

See the Cavendish Experiment (EX-5550A) on page 349 for a new video analysis method of tracking the laser beam.



Order Information

Cavendish Gravitational Torsion Balance AP-8215B

Required:

X-Y Adjustable Diode Laser OS-8526A p. 317

45 cm Stainless Steel Rod ME-8736 p. 204

Large Table Clamp ME-9472 p. 207

Replacement Supplies:

Torsion Bands (2 pack) –
Cavendish Gravitational Torsion Balance AP-8218

Cavendish Gravitational Torsion Balance

Replacement Spheres AP-8219A

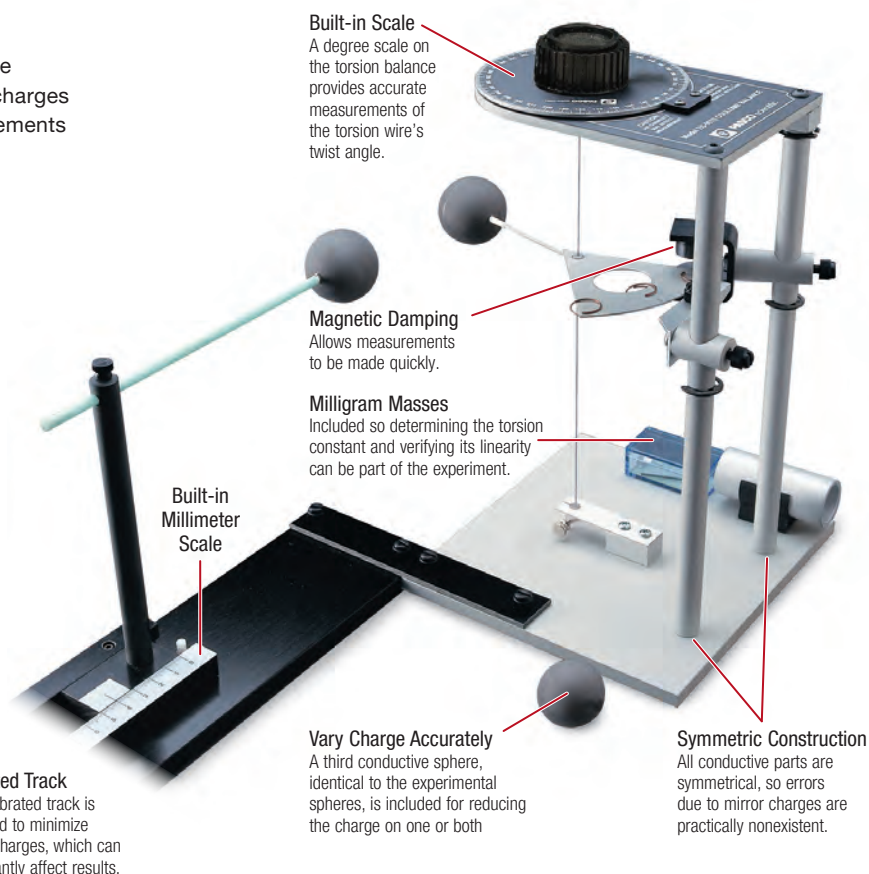
Coulomb's Law Apparatus

ES-9070

- Accurately measure charge, force, and distance
- Symmetric design minimizes stray and mirror charges
- Magnetic damping for quick, accurate measurements

How It Works:

A conductive sphere is mounted on the end of an insulating, counterbalanced rod and suspended from a thin torsion wire. An identical sphere is mounted on a calibrated linear track. This second sphere can be positioned at various distances from the first. When the conductive spheres are charged, the force between them is proportional to the twist of the torsion wire that is required to bring the balance back to its equilibrium position. Beginning students can determine the Inverse Square Law in a simple experiment. Advanced students can perform a more sophisticated investigation into all the variables of electrostatic repulsion.



Specifications:

Torsion Balance:

Torsion Assembly: 38 mm dia. conductive sphere on 12 cm rod with counterbalance vane

Torsion Wire: equals 10-6 Newtons/degree

Degree Plate: 1° increments

Magnetic Damping: dampens oscillations for quick measurements

Calibrated Linear Track:

Sphere: 38 mm dia. conductive sphere

Range of Movement: 350 mm in 1 mm increments

Material: phenolic (to minimize mirror charges)

Miscellaneous Equipment:

Charging Probe: 17 cm long plus 1.5 m cable; banana plug connector; 200 $\mu\Omega$ internal resistance

Calibration Masses: 50 mg (1), 20 mg (2)

Conductive Sphere on Insulating Thread: for reducing charge by fixed ratios

Spare Torsion Wire: 3 m

Shipping Information:

Size: 28 x 38 x 61 cm (11 x 15 x 24 in.)

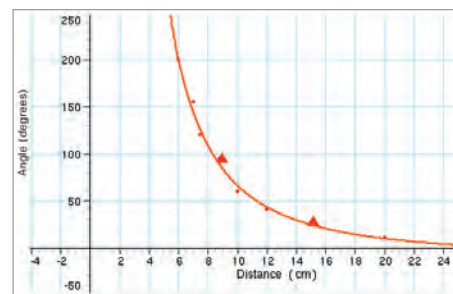
Weight: 9.5 kg, 21 lbs

Additional Equipment

To perform a basic experiment, the conductive spheres can be charged with a piezoelectric gun or by contact with a charged rod. This allows the Inverse Square Law to be verified with reasonable accuracy. However, for more accurate and thorough investigations, we strongly recommend the following additional equipment (see ordering information):

- **Kilovolt Power Supply**, which provides a fixed and repeatable charge. The charge can be refreshed before each measurement, which practically eliminates errors due to leakage currents.

- **Basic Electrometer and a Faraday Ice Pail**, for accurate measurement of the charge on the spheres (required only if you wish to measure the Coulomb Constant).



Actual data of the Angle (force) vs. Distance

Order Information

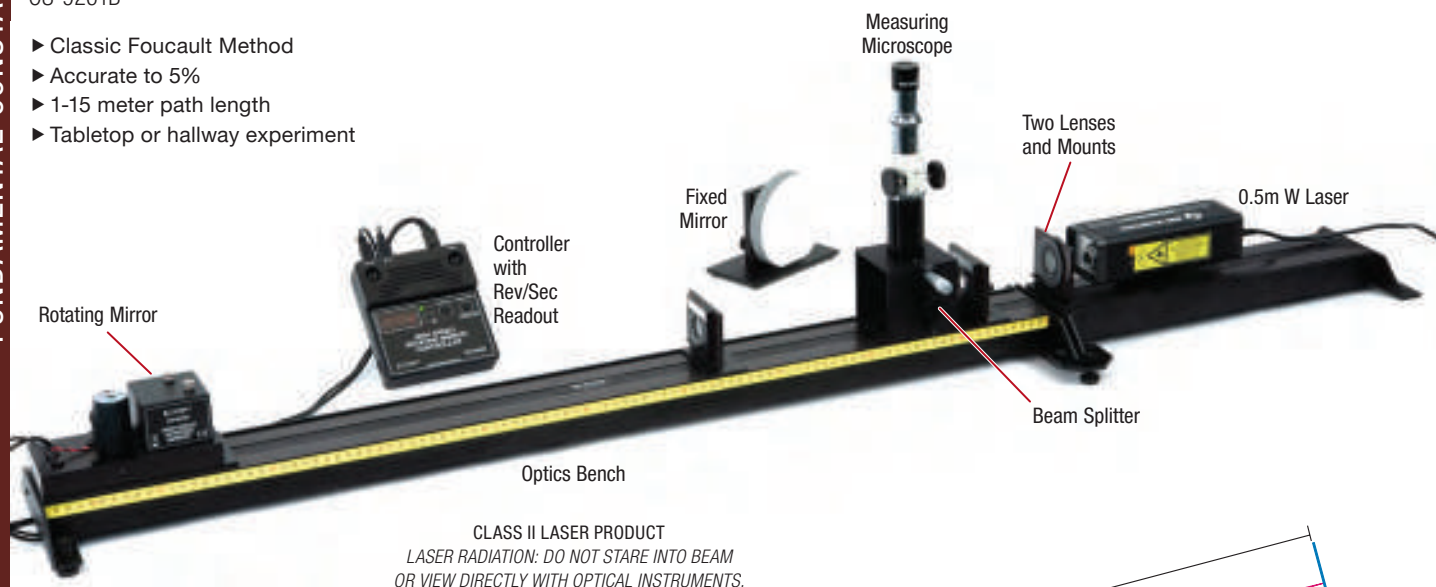
Coulomb's Law Apparatus.....	ES-9070
Recommended:	
Kilovolt Power Supply.....	SE-9586 p. 273
Basic Electrometer.....	ES-9078A p. 232
Faraday Ice Pail	ES-9042A p. 233
Charge Producers and Proof Plane	ES-9057C p. 233
Coulomb's Law Experiment	EX-9930B p. 368

Speed of Light

Complete Speed of Light Apparatus

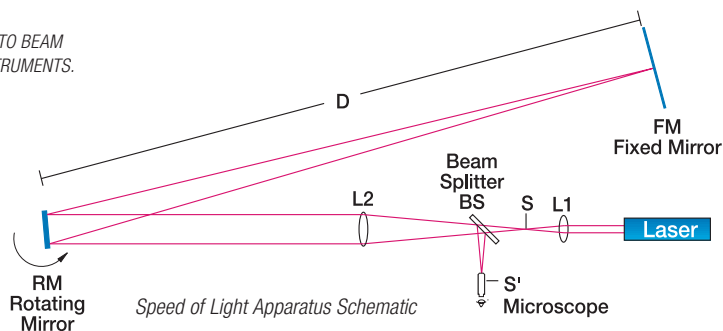
OS-9261B

- ▶ Classic Foucault Method
- ▶ Accurate to 5%
- ▶ 1-15 meter path length
- ▶ Tabletop or hallway experiment



How It Works – The Foucault Method

1. The first observation is made when the rotating mirror is not rotating. Light from a He-Ne laser is reflected from the rotating mirror and focused onto the fixed mirror. The fixed mirror reflects the image back onto the rotating mirror, which in turn reflects the light back through the lenses to reform the image, where it can be observed with the microscope.
2. The second observation is made when the rotating mirror is rotating. Since it takes a finite amount of time for the light to traverse the distance between the fixed and rotating mirrors, the rotating mirror is in a slightly different position when the light returns after reflecting off the fixed mirror. This produces a displacement, which can be measured with the microscope.
3. The displacement between the first and second observations is proportional to the transit time of the light and the angular velocity of the rotating mirror. With a very straightforward calculation, the speed of light can be calculated.



Order Information

Complete Speed of Light Apparatus	OS-9261B	
Parts Available Separately:		
Laser Alignment Bench	OS-9172	p. 317
Mini Laser with Bracket	OS-8514	p. 317
Speed of Light Experiment	EX-9932A	p. 387

OS-9261B Includes:

- 1 m Optics Bench
- Laser Alignment Bench
- Mini Laser with Bracket
- Double Convex Lens, 48 mm F.L.
- Plano Convex Lens, 252 mm F.L.
- Calibrated Polarizer
- Component Carrier

High Speed Rotating Mirror with Controller

OS-9263B



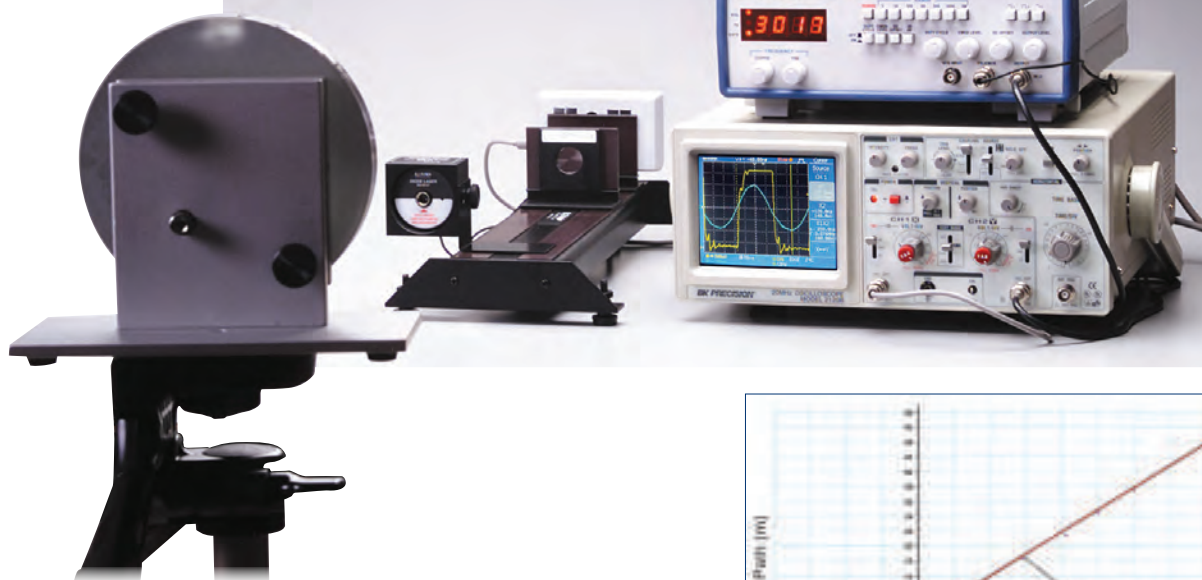
Order Information

High Speed Rotating Mirror	OS-9263B
----------------------------------	----------

Laser Speed of Light System

AP-8586

- Easy setup
- Accurate results
- Low cost

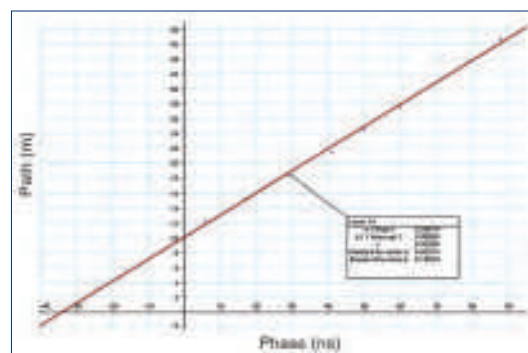
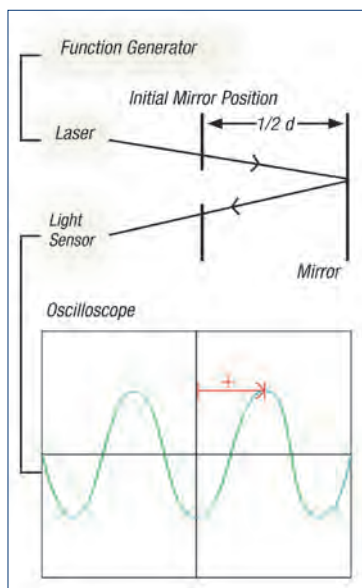


The Laser Speed of Light System is a low cost, yet effective method of measuring the speed of light. While it does not duplicate the classic Foucault Method, its ease of use gives every student the opportunity to perform the experiment.

How It Works:

A function generator is used to modulate the light from the laser at 3 MHz. This light is then reflected from a mirror and focused onto a light receiver. An oscilloscope is used to observe the modulated light, and the phase of the signal is noted as the baseline value for phase.

The mirror is moved back, increasing the distance that the light travels. Since it takes more time for the light to travel from the laser to the sensor, the phase of the signal on the oscilloscope increases. The phase at each successive mirror position is recorded and compared to the baseline value. The mirror is moved back several more times to get a reasonable number of data points. For each mirror position, the additional path length (d) is graphed versus the phase difference (t).



A linear fit is applied to the data, and the slope of the fit represents $\Delta d/\Delta t$, or the speed of light.

Includes:

- Diode Laser, Component Carrier (2)
- Laser Alignment Bench
- +127 mm Lens
- Light Receiver
- Stainless Steel Mounting Pads (4)
- Concave Mirror
- Coaxial Cable – RCA male to BNC male
- Coaxial Cable – 3.5 mm phone plug to BNC male
- Coaxial Cable – BNC male to male

Order Information

Laser Speed of Light SystemAP-8586

Required:

Wide Range Function GeneratorSB-9549A p. 271

30 Meter Measuring TapeSE-8712A p. 208

Standard Photo Tripod

Replacement Part:

Speed of Light Diode LaserOS-8475

Multi-Channel Analyzer

Advanced Nuclear Spectroscopy System, (Win/Mac) USB

SN-7901B

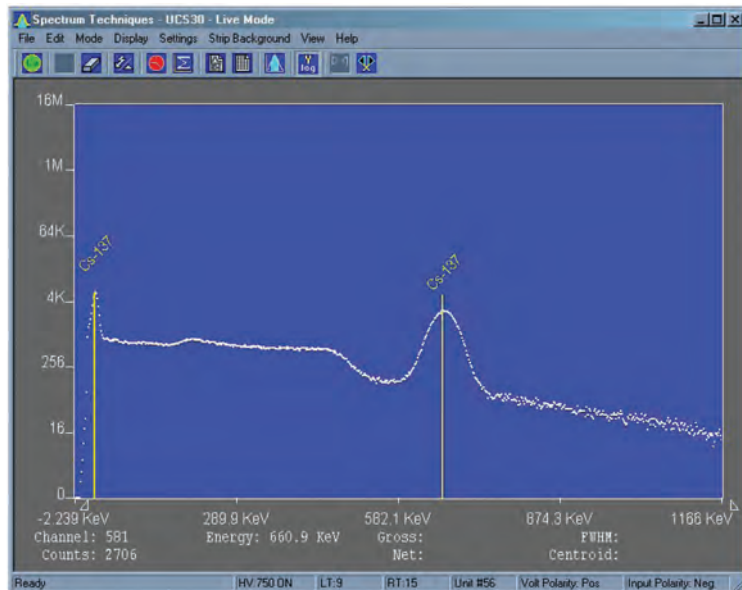
- Sophisticated spectroscopy system
- Multi-channel analysis

Designed for spectroscopy applications, the Universal Computer Spectrometer offers complete support for standard scintillation detectors as well as multi-channel scaling for decay and time-related studies. The multi-channel analyzer contains many advanced features, including a computer-controlled amplifier and high voltage for G-M tubes, upper- and lower-level discriminators, data memory, and a comprehensive software package.

The sources are USNRC License Exempt (US only). Outside the US, consult your local laws and regulations.

Features:

- **Variable Voltage:** A regulated high voltage of 0 to 1280 V is supplied with computer control (1 mA maximum, 5 V increments).
- **Amplifier:** On-board combination preamplifier/amplifier for use with scintillation detectors and PMTs.
- **Complete Computer Control:** When used in MCA mode, the software provides complete computer control of all features including preset live/real-time, preset count, unlimited regions-of-interest and centroid, gross and net area calculations.
- **Multiple Memory Buffers:** In addition to on-board hardware data memory, the spectrometer provides three software memory buffers for holding spectra. A background spectrum may be collected over a long counting period and stored in the background buffer.
- **Peak Labeling:** With ISOMATCH, an isotope library file, users can quickly identify peaks by superimposing characteristic isotope emission lines over their spectrum. Isotope and energy information are also provided.



Main screen display for Universal Computer Spectrometer

Specifications:

Physical Hardware: Interface card or box includes pre-amplifier, amplifier, detector high voltage, 1024 channel analyzer with data memory, LLD and ULD

ADC: Wilkinson-type with 80 MHz clock and computer selected conversion gain of 256, 512, or 1024 channels

High Voltage: 0-1280 V, 1 mA maximum Amplifier: Preamplifier/amplifier combination; computer controlled coarse/fine gain from 2x to 1000x

Modes: MCA for pulse height analysis, or MCS for half-life decay or other time-related studies

Software Energy Calibration: 2-point linear or 3-point quadratic converts cursor position reading directly to energy units

Computer Software Display: Vertical scale adjusts from 32 to 16 M and LOG display; horizontal 1024 channels with expansion down to 128 channels

ISOMATCH Software: Isotope library text file with peak markers and labeling for overlaying on spectrum for quick isotope identification; library may be edited and expanded.

Includes:

- Universal Computer Spectrometer, USB
- NaI (TI) Scintillation Probe
- Gamma Sources (8)
- Connection Cables
- Installation, Instruction, and Experiment CDs (2)

Order Information

Advanced Nuclear Spectroscopy System,
(Win/Mac) USB..... SN-7901B

***Note:** Purchased Sources are "Non-Cancellable" and "Non-Returnable".
See Radioactive Source Disclaimer on the Order Information page 408.

Intermediate Nuclear Laboratory System (Win/Mac)

SN-7900B

- Mac®, Windows®, or standalone option
- Complete system

PASCO's most sophisticated, standalone G-M System supports a wide range of experiments with alpha, beta and gamma radiation. Includes a versatile scaler, a G-M Tube with a mount and trays, and a full set of radioactive sources and absorbers.

The Sources are USNRC License Exempt (US only). Outside the US, consult local laws and regulations.

Features:

- **Preset Timing and Counting Intervals:** (in seconds) 1-9, 10-90, 100-900, 1K-9K, 10K-90K, 100K- 900K. Intervals are selected using the Preset switch.
- **Digital Display:** A bright 6-digit digital readout uses extra-large LEDs for clear readout in most ambient light conditions.
- **Built-in Power Supply:** 0 to 1200 volts for the G-M Probe.
- USB and serial interface to Mac and PC

Advanced Scaler/Timer

The Radiation Counter SN-7907 is a versatile, general purpose Scaler/Timer.

Sensitive G-M Probe

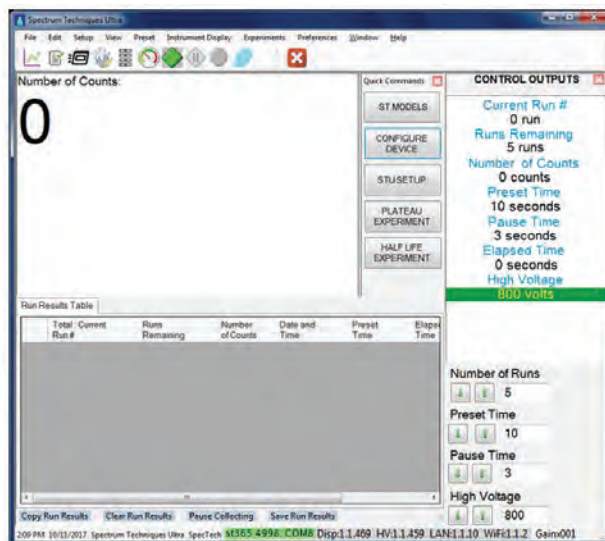
- Suitable for alpha, beta, and gamma radiation detection
- The rugged and versatile mount is made of sturdy plastic for years of rugged use. It comes with one sample holder and 10 shelf positions.

Large Variety of Absorbers

The Absorber Set SN-8111A includes four lead, ten aluminum sheets, two polyethylene, two plastic, and two aluminum foil absorbers, ranging from 5 mg/cm² to 7200 mg/cm².



***Note:** Purchased Sources are "Non-Cancellable" and "Non-Returnable". See Radioactive Source Disclaimer on the Order Information page 408.



Main screen display from Spectrum Techniques Ultra software

Computer Compatibility

The bi-directional STU software allows full control of the Radiation Counter from the computer. STU provides real-time display of a simulated analog rate-meter with auto-ranging, digital ratemeter in CPM or CPS, count, elapsed time, preset count, preset time, acquisition time, and run number. Data is loaded into spreadsheet-compatible files.

Five Radioactive Sources

1. Po-210:	0.1 μ Ci,	138 days,	α
2. Sr-90:	0.1 μ Ci,	28.6 years,	β
3. Co-60:	1 μ Ci,	5.27 years,	β, γ
4. Tl-204:	0.25 μ Ci,	3.78 years,	β, γ
5. Cs-137:	0.25 μ Ci,	30.2 years,	β, γ

The five sources are USNRC License Exempt (US only). Outside the US, consult your local laws and regulations.

Includes

1. SN-7907 Radiation Counter with STU software and manual
2. SN-7970A G-M Probe (35 mm) and stand
3. USB Cable
4. SN-8111A Calibrated Absorber Set (20)
5. SN-7972A Radioactive Sources (5)
6. Two CDs with installation instructions and nuclear science experiments



Order Information

Intermediate Nuclear Laboratory System
 (Win/Mac)..... SN-7900B
 Required:
 Isotope Generator Kit (Barium-137 m)..... SN-7995A p. 337

Radiation Counters

Radiation Counter

SN-7907

- ▶ Available only for 110 VAC



Wireless Radiation Counter has LCD display.

This Radiation Counter supports G-M detectors, as well as scintillation detectors. It can be used standalone or connected to a computer through USB, Ethernet, or Wi-Fi. The control software stores data in a format that can easily be transferred directly to common spreadsheet programs.

Specifications:

Power: 110 VAC Adapter 9 VDC at 1200 mA

Variable High Voltage: 0 to 1200 V, in 10 V increments

Display: 16 character LCD

Housing: Plastic housing with metal face plate

Dimensions: 21.6 cm W x 15.2 cm D x 6.4 cm H

Computer Connectivity: USB, Ethernet, or Wi-Fi for Mac and Windows

Mobile Device Connectivity: Wi-Fi

Detector Connectors: BNC and MHV

Supported Detectors: G-M and scintillation

Includes:

- Spectrum Techniques Ultra Software for Windows and Mac
- 110 VAC to 9 VDC Power Adapter

Order Information

Radiation Counter SN-7907

G-M Probe with Sample Holder

SN-7970A

Similar to the Student G-M Tube except that the larger, 35 mm diameter window provides excellent photon efficiency for detecting low activity samples. The SN-7970A G-M Probe has a 200 μ s dead time, contains 10 shelf positions and is designed to accommodate the larger G-M Probe. The probe can be removed from the holder and comes with a standard BNC connector cable.



Specifications:

Mica Window: ≤ 2 mg/cm²

Probe Dimensions: 11.25 x 3.5 cm (4.5 x 1.4 in.) OD, excluding connector

Operating Voltage: 900 V, 150 V plateau

Order Information

G-M Probe with Sample Holder SN-7970A

Wireless Geiger Counter



PS-3238

The PASCO Wireless Geiger Counter counts beta, gamma and alpha radiation particles as they enter the Geiger-Müller detector tube inside the counter. Designed for easy mounting, the Geiger Counter provides superior position control in inverse square law labs, as well as an audible beep to indicate the detection of ionizing radiation. The front plastic snout fits conveniently inside the NU-3344 Sample Holder stand (available separately), which stabilizes the front of the counter's detector tube exactly 1 cm from the first slot in the holder.



With the Wireless Geiger Counter, students can wirelessly control the high voltage supplied to the Geiger-Müller tube inside the counter, enabling them to make measurements of counts/interval for different tube voltages. They can also plot counts/interval versus tube voltages to experimentally observe the Geiger plateau characteristics of the tube.

Specifications:

Sensitivity: Alpha, Beta, Gamma

Count Detection: Switchable audio signal

Gas Filling: Ne +Halogen

Effective Tube Diameter: 9.1 mm

Window Thickness: 1.5 to 2.0 mg/cm²

High Voltage Control Range: 150 VDC to 650 VDC

Standard Operating Voltage: 500 VDC

Includes:

- Wireless Geiger Counter
- Micro USB Cable (PS-3584)
- Threaded handle for mounting the sensor to a ring stand

Order Information

Wireless Geiger Counter PS-3238

Geiger Counter Sample Holder

NU-3344

The PASCO Geiger Counter Sample Holder is designed for easy mounting and superior position control of the PS-3238 Wireless Geiger Counter for inverse square law labs, radiation shielding labs, and other radiation labs. The front plastic snout on the Wireless Geiger Counter is designed to fit conveniently inside the Sample Holder stand, which stabilizes the front of the counter's detector tube exactly 1 cm from the first slot in the holder.

The stand includes a radioactive sample holder tray and 5 pieces of 7 cm x 7 cm aluminum shielding material. The stand has eight slots designed to hold the included radioactive sample holder tray or shielding material. Each slot in the holder is spaced 1 cm apart to make changing the spacing between the Geiger Counter, radioactive sample, or shielding materials quick and easy.



Includes:

- Stand with 8 slots
- Radioactive sample tray
- 7cm x 7cm aluminum shielding material (5)

Order Information

Geiger Counter Sample Holder NU-3344

The following sources are mounted in 2.5 cm diameter sealed plastic disks. All sources and isotopes on this page are USNRC License Exempt (US only). Outside the US, consult your local laws and regulations. Shown below are the isotopes, activity, half-life, and types of radiation (alpha- α , beta- β , gamma- γ).

Radioactive Sources (set of 3)

SN-8110



1. Po-210	0.1 μ Ci	138 days	α
2. Sr-90	0.1 μ Ci	28.6 years	β
3. Co-60	1 μ Ci	5.27 years	β, γ

Order Information

Radioactive Sources
(set of 3) SN-8110

***Note:** "Non-Cancellable" and "Non-Returnable".
See Radioactive Source Disclaimer on the
Order Information page 408.

Radioactive Sources (set of 5)

SN-7972A



1. Po-210	0.1 μ Ci	138 days	α
2. Sr-90	0.1 μ Ci	28.6 years	β
3. Tl-204	0.25 μ Ci	3.78 years	β
4. Co-60	1 μ Ci	5.27 years	β, γ
5. Cs-137	0.25 μ Ci	30.2 years	β, γ

Order Information

Radioactive Sources
(set of 5) SN-7972A

***Note:** "Non-Cancellable" and "Non-Returnable".
See Radioactive Source Disclaimer on the
Order Information page 408.

Individual Sources



Order Information

Po-210*	0.1 μ Ci	138 days	α	SN-9085
Sr-90*	0.1 μ Ci	28.6 years	β	SN-9796
Tl-204*	1 μ Ci	3.78 years	β	SN-9797
Co-60*	1 μ Ci	5.27 years	β, γ	SN-9794
Cs-137*	10 μ Ci	30.08 years	β, γ	SN-7938
Cs-137*	5 μ Ci	30.2 years	β, γ	SN-9795
Cs-137*	0.25 μ Ci	30.2 years	β, γ	SN-7942
Tl-204*	0.25 μ Ci	3.78 years	β	SN-7941

***Note:** "Non-Cancellable" and "Non-Returnable".
See Radioactive Source Disclaimer on the
Order Information page 408.

Gamma Sources (set of 8)

SN-7949A



1. Co-60	1 μ Ci	5.27 years	β, γ
2. Na-22	1 μ Ci	2.60 years	β, γ
3. Mn-54	1 μ Ci	313 days	γ
4. Cs-137	0.25 μ Ci	30.2 years	β, γ
5. Ba-133	1 μ Ci	10.5 years	γ
6. Cd-109	1 μ Ci	464 days	γ
7. Co-57	1 μ Ci	270 days	γ
8. "UNKNOWN": mixture of Cs-137 and Zn-65 for student testing.			

Cs-137 is 0.25 μ Ci or lower.

Order Information

Gamma Sources
(set of 8) SN-7949A

Absorbers (set of 20)

SN-8111A



This set of 20 calibrated absorbers includes 4 lead, 2 plastic, 10 aluminum, 2 polyethylene, and 2 aluminum foil absorbers. Absorbers vary in density from 5 mg/cm² to 7200 mg/cm².

Order Information

Absorbers (set of 20) SN-8111A



WARNING! This product can expose you to Lead, which is known to the State of California to cause cancer, birth defects, or other reproductive harm. For more information go to www.P65Warnings.ca.gov.

***Note:** "Non-Cancellable" and "Non-Returnable".
See Radioactive Source Disclaimer on the
Order Information page 408.

Isotope Generator Kit (Barium-137 m)

SN-7995A



This Cs-137/Ba-137m Isotope Generator is used to demonstrate the properties of radioactive decay. Based on the original Union Carbide patented design, it offers exceptional performance, ease-of-use, and safe operation.

Each generator contains 10 μ Ci of Cs-137. The generator can produce up to 1000 small aliquots of the short-lived Ba-137m isotope with a half-life of 2.6 minutes.

Each generator is supplied with 250 mL of eluting solution (0.9% NaCl in 0.04M HCl). The parent isotope Cs-137 with a half-life of 30.1 years beta decays (94.6%) to the metastable state of Ba-137m. This further decays by gamma emission (662 keV) with a half-life of 2.6 min. to the stable Ba-137 element. During elution, the Ba-137m is selectively "milked" from the generator, leaving behind the Cs-137 parent. Regeneration of the Ba-137m occurs as the Cs-137 continues to decay, re-establishing equilibrium in less than 1 hour.

Approximately 30 minutes after elution, the residual activity of the Ba-137m sample has decayed to less than one thousandth of its initial activity, making it safe for disposal. When used with the eluting solution supplied, bleed-through of the parent Cs-137 is less than 50 Bq/mL, affording a long working life. Each kit is supplied with the generator, syringe, tube, 250 mL of solution, and a storage case.

Order Information

Isotope Generator Kit
(Barium-137 m) SN-7995A

***Note:** "Non-Cancellable" and "Non-Returnable".
See Radioactive Source Disclaimer on the
Order Information page 408.

Cloud Chamber

Diffusion Cloud Chamber

SE-7943

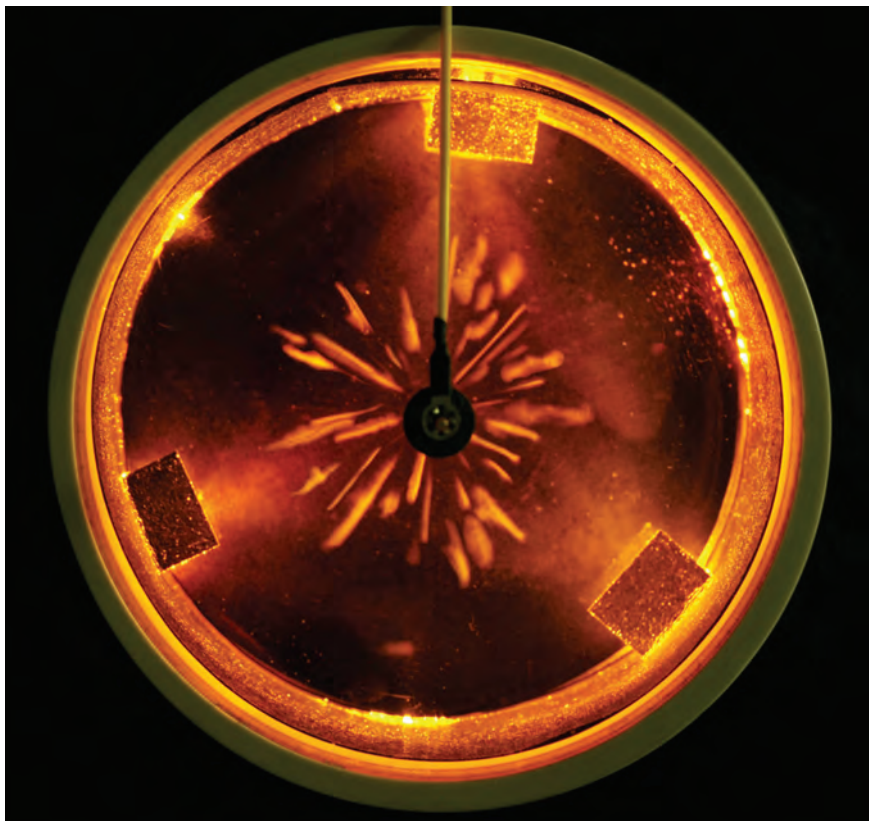
- ▶ No dry ice required
- ▶ View cosmic rays
- ▶ Built-in illumination

How It Works

The bottom of the chamber is cooled by circulating ice water through the base and further cooling it to -35°C with a Peltier device. Alcohol placed in the chamber wicks up the inside chamber lining where it evaporates in the warmer region of the chamber and diffuses downward. The alcohol vapor is then cooled near the chamber bottom and becomes super saturated.

As energetic alpha and beta particles from a radioactive source pass through the alcohol vapor, the vapor condenses, forming droplets that appear as tracks in the strong chamber cross-lighting.

Particle tracks are visible from radioactive particles given off by the Pb-210 source at the center. The dense straight tracks are produced by alpha particles and the fainter, crooked tracks are produced by beta particles.



Includes:

- Cloud Chamber
- 12 VDC Power Adapter (6 A)
- Water Circulation Pump
- Two Rubber Hoses
- Extraction Pipette
- Source Holder and Stopper
- High Voltage Connection Cable
- SpecTech™ Coupon for Pb-210 Source Needle

Features:

- ▶ Powered by 12V DC power adapter
- ▶ Built-in LED lamps for illuminating the particle trails
- ▶ Uses ice water instead of dry ice
- ▶ Water circulation pump
- ▶ Built-in high voltage ($\sim 800\text{V}$) power supply for clearing the chamber of unwanted ions

Specifications:

Diameter: 15 cm 12 VDC Power Adapter (6 A)

Water Circulation Pump: 120 V/60 Hz, 3 W, 180 liter/hr

Built-in High Voltage Source: $\sim 800\text{VDC}$ with $108\ \Omega$ protection resistor

Rubber Hoses: 0.25" ID (6.4 mm ID), 60 cm long

High Voltage Connection Cable:

22 cm long, Banana plug to ring lug eight amber LEDs



***Note:** Purchased Sources are "Non-Cancellable" and "Non-Returnable". See Radioactive Source Disclaimer on the Order Information page 408.

Order Information

Diffusion Cloud Chamber (15 cm diameter)..... SE-7943

Diffusion Cloud Chamber (15 cm diameter) - No Source SE-7940

Required:

Ice Water

Recommended:

Pb-210 Source Needle..... SE-7945

The Needle Source is USNRC License Exempt (US only).

Download **FREE** PASCO Capstone Experiments

Over 60 classic physics experiments for use with PASCO equipment and software

The following pages present classic experiments in physics performed with PASCO apparatus. Manuals can be downloaded at www.pasco.com. Interfaces and software, where indicated, should be ordered separately. Everything else is included in the experiment: apparatus, sensors (when needed), and accessories.

EXPERIMENT #	EXPERIMENT LIST	PAGE #
Mechanics		
EX-5602	Projectile Motion	340
EX-5503B	Newton's Law	341
EX-5501	Atwood's Machine	342
EX-5504A	Hooke's Law	342
EX-5605	Centripetal Force on a Pendulum	343
EX-5506	Centripetal Force	343
EX-5615	Materials Stress-Strain	344
EX-5509B	Impulse	345
EX-5510C	Conservation of Momentum	345
EX-5611	Ballistic Pendulum	346
EX-9935	Conservation of Energy	347
EX-5612	Conservation of Energy II	348
EX-5513A	Work Energy Theorem	348
EX-5550A	Cavendish	349
EX-9909	Archimedes' Principle	350
Rotation and Oscillations		
EX-5616	Rotational Inertia	351
EX-5564	Static Equilibrium	352
EX-5517C	Conservation of Angular Momentum	353
EX-5618	Physical Pendulum	353
EX-5551A	Driven Damped Cart Oscillations	354
EX-5521A	Torsional Pendulum	355
EX-5563	Coupled Pendula	355
EX-5523A	Chaos	356
EX-5522A	Driven Damped Harmonic Oscillations	357
Structures		
EX-5556	Basic Bridges	358
EX-5555	Shaking Tower	359
EX-5548	Bridge Vibration	360
Thermodynamics		
EX-5624A	Specific Heat	361
EX-5625	Electrical Equivalent of Heat	362
EX-5627	Ideal Gas Law	363
EX-5529A	Blackbody Radiation	364
EX-5630	Heat Engine Cycles	365
EX-5631	Ratio of Specific Heat	366

EXPERIMENT #	EXPERIMENT LIST	PAGE #
Electromagnetism		
EX-5532	Electrostatic Charge	367
EX-9930B	Coulomb's Law	368
	Charge of an Electron	369
EX-5533	Capacitance	370
EX-5534	Resistivity	371
EX-5535	Ohm's Law	372
EX-5536	RC Circuit	372
EX-5537	LRC Circuit	373
EX-5538	Kirchhoff's Circuit Law	374
EX-5640	Magnetic Fields of Coils	376
EX-5552	Ampere's Law	377
EX-5641	Faraday's Law of Induction	378
EX-5566 NEW	Ferromagnetic Hysteresis	379
EX-5568 NEW	Magnetic Force on a Current-Carrying Wire	375
Waves & Optics		
EX-9952	Mechanical Waves	380
EX-5542	Vibrating Strings	381
EX-5565	Sound of Vibrating Strings	381
EX-9987	Reflection & Refraction	382
EX-9988	Telescope/Microscope	383
EX-5547A	Light Intensity vs. Distance	383
EX-5645	Interference and Diffraction of Light	384
EX-5543A	Polarization	385
EX-5544A	Brewster's Angle	386
EX-9932A	Speed of Light	387
Quantum		
EX-5546B	Atomic Spectra	388
EX-5549A	Photoelectric Effect	389
EX-5560	Hall Effect	390
EX-5561	Franck-Hertz	391
EX-5562	Zeeman Effect	392



Download This Experiment

Each experiment manual and the PASCO Capstone™ workbook files may be downloaded for free at pasco.com/CapstoneExperiments

- **Experiment Manual:** A detailed experiment manual helps ensure student success.
- **PASCO Capstone Workbook File:** PASCO Capstone workbook files are included for each experiment. These files contain workbooks with step-by-step instructions and embedded live data displays to support students through the lab.
- **Teacher Files:** Log into PASCO Portal to access the Word version of the instructions, sample Capstone data files, and graphics files.

Mechanics

Projectile Motion Experiment

EX-5602

Concepts:

- Independence of x- and y-motion
- Muzzle velocity vs. time of flight
- Angle vs. horizontal range

The Wireless Smart Gate and Time-of-Flight Accessory are used with the Mini Launcher to measure both muzzle velocity and time of flight.



Muzzle Velocity vs. Time of Flight

Students fire the projectile at three different velocities from the same height. The Photogate and Time-of-Flight Accessory are used to measure the time of flight at each muzzle velocity. Students are surprised to find that the time of flight is not related to the muzzle velocity at 0° launch angle.

Angle vs. Horizontal Range

The angle of launch is varied and the horizontal range is measured for each angle. Students produce a graph of angle vs. horizontal range, and use its equation to find the angle of maximum range. This experiment is conducted in two variations:

- Projectile is fired from a higher vertical position than its landing position
- Projectile is fired from the same vertical position as its landing position

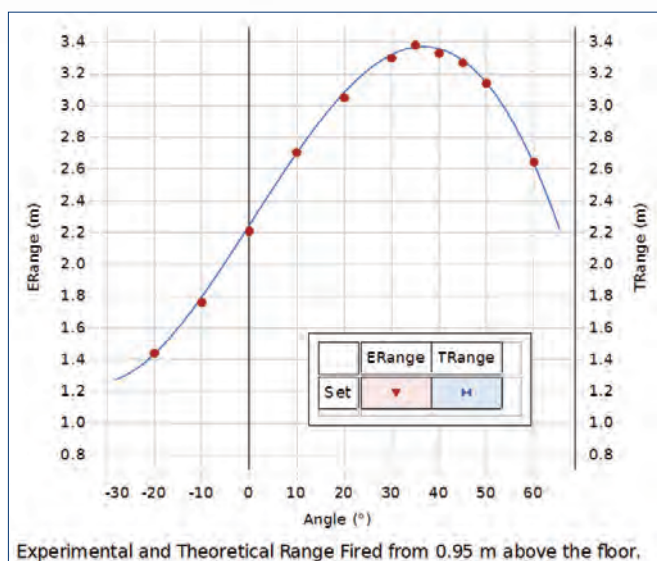
Students are asked to use the kinematic equations to predict the horizontal range, given a launch angle and muzzle velocity. Carbon paper and a bullseye can be used to test their hypotheses.

PASCO Advantage:

PASCO Projectile Launchers are designed for repeatable and accurate launches. In addition, photogates and other accessories are designed to work seamlessly with our Projectile Launchers. These features allow student predictions and calculations from the kinematic equations to be empirically verified.

Includes:

- | | |
|------------------------------|----------|
| • Mini Launcher | ME-6825B |
| • Time-of-Flight Accessory | ME-6810A |
| • Phone Jack Extender Cable | PI-8117 |
| • Wireless Smart Gate | PS-3225 |
| • Photogate Mounting Bracket | ME-6821A |
| • Carbon Paper (100 Sheets) | SE-8693 |
| • Large C Clamp (6 Pack) | SE-7285 |
| • Plumb Bobs (10 Pack) | SE-8728 |
| • 30 Meter Measuring Tape | SE-8712A |



Experimental and Theoretical Range Fired from 0.95 m above the floor.

Students can use their data to determine which launch angle produces the maximum horizontal range.

Download This Experiment

The FREE experiment files include a pdf of the student instructions and a PASCO Capstone™ workbook file. Download this experiment at pasco.com/CapstoneExperiments.

Order Information

Projectile Motion Experiment.....EX-5602

Required:

PASCO Capstone Softwarepp. 8-11

View the 550 or 850 Universal Interface-compatible version of this experiment (EX-5502) online at pasco.com/capstoneexperiments

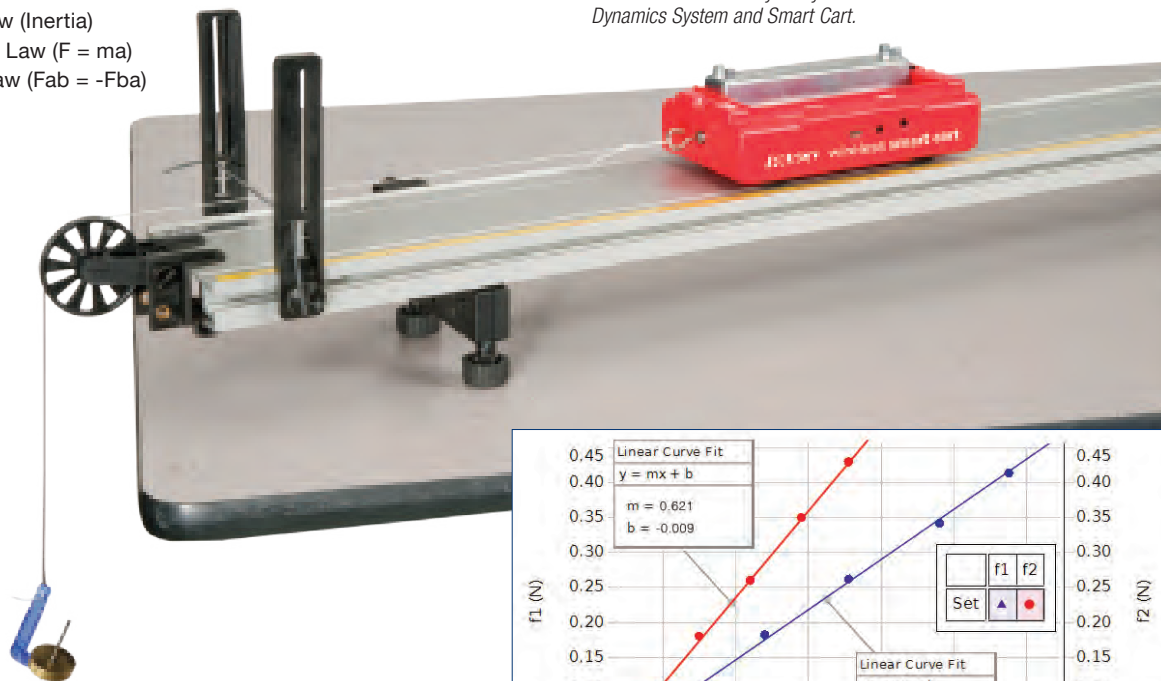
Newton's Laws Experiment

EX-5503B

Concepts:

- Newton's First Law (Inertia)
- Newton's Second Law ($F = ma$)
- Newton's Third Law ($F_{ab} = -F_{ba}$)

Students can effectively study Newton's Second Law with a Dynamics System and Smart Cart.

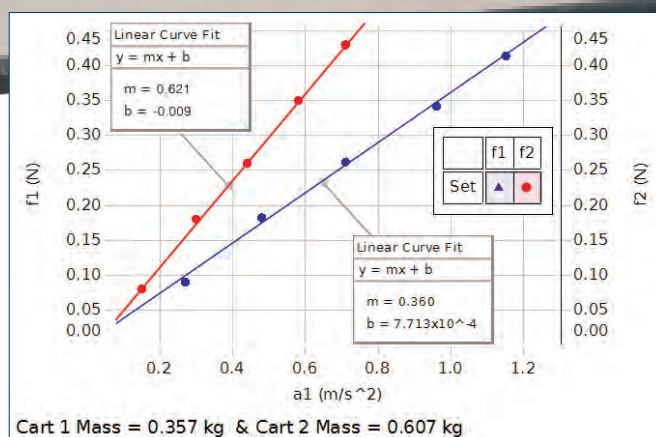
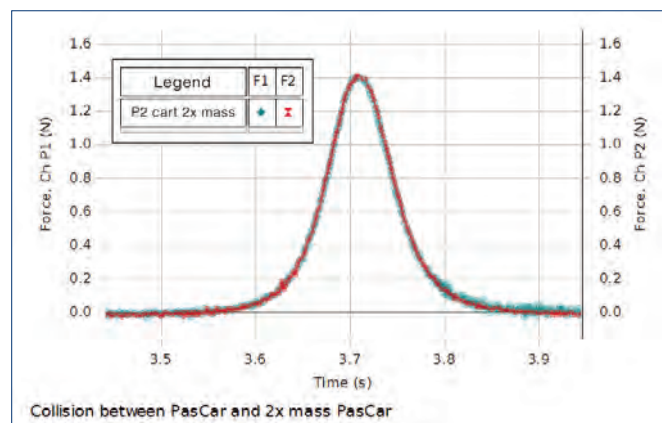


This collection of equipment lets students discover or experimentally determine all three of Newton's Laws.

- **Newton's First Law** – Students examine an object's motion to see if it changes when forces are applied or not.
- **Newton's Second Law** – Students use the Smart Cart to discover the relationships between force, mass, and acceleration.
- **Newton's Third Law** – Using two Smart Cart Force Sensors, students prove that forces between objects are equal in magnitude yet opposite in direction. These experiments include both tug-of-war exercises and collisions between cars.

PASCO Advantage:

The Smart Cart has all the sensors required, which makes setup very quick and easy. The integration between the probeware and equipment helps students focus on the physics of each experiment.



Force vs. acceleration data for the cart as it experiences changing net force

Includes:

- | | |
|---------------------------------|----------|
| • Smart Cart (Red) | ME-1240 |
| • Smart Cart (Blue) | ME-1241 |
| • PASCAR Cart Mass (set of 2) | ME-6757A |
| • Dynamics Track Feet (Pair) | ME-8972 |
| • Mass and Hanger Set | ME-8979 |
| • Elastic Bumper | ME-8998 |
| • Super Pulley with Clamp | ME-9448B |
| • 1.2 m Aluminum Dynamics Track | ME-9493 |
| • Friction Block - IDS | ME-9807 |
| • Braided Physics String | SE-8050 |
| • Smart Cart Rod Stand Adapter | ME-1244 |

Download This Experiment

The FREE experiment files include a pdf of the student instructions and a PASCO Capstone™ workbook file. Download this experiment at pasco.com/CapstoneExperiments.

Order Information

Newton's Laws Experiment.....EX-5503B

Required:

Bluetooth 4.0 enabled computer

PASCO Capstone Software.....pp. 8-11

Mechanics

Atwood's Machine Experiment

EX-5501

Concepts:

- ▶ Newton's 2nd Law of Motion
- ▶ Newton's 2nd Law of Rotational Motion
- ▶ Rotational Inertia

In this classic experiment, students use a very low mass, low friction pulley to measure the changing velocity of the unbalanced mass system. Students interpret the slope of the velocity graph as acceleration. They examine the effect of the pulley's rotational inertia and estimate the friction forces based on experimental data.

PASCO Advantage:

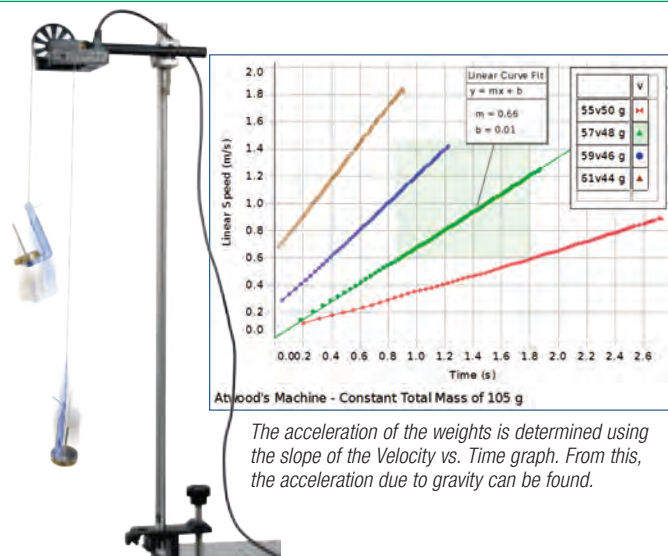
The Super Pulley/Photogate System makes it easy for students to set up the apparatus and take data. Analysis includes accounting for friction and the rotational inertia of the pulley.

Includes:

- Photogate & Pulley System ME-6838A
- Mass and Hanger Set ME-8979
- Universal Table Clamp ME-9376B
- Stainless Steel Rod, 60 cm Threaded ME-8977
- Multi-Clamp ME-9507
- Braided Physics String SE-8050

Download This Experiment

The FREE experiment files include a pdf of the student instructions and a PASCO Capstone™ workbook file. Download this experiment at pasco.com/CapstoneExperiments.



The acceleration of the weights is determined using the slope of the Velocity vs. Time graph. From this, the acceleration due to gravity can be found.

Order Information

Atwood's Machine Experiment..... EX-5501

Required:

550 or 850 Universal Interface* pp. 20-23
 PASCO Capstone Software pp. 8-11
 Balance or Scale p. 212
 Digital Calipers SE-8710 p. 208

* This experiment can be performed using the 550 or 850 Universal Interface or AirLink with Digital Adapter.

Hooke's Law and Spring Potential Experiment

EX-5504A

Concepts:

- ▶ Relationship between force and spring deformation
- ▶ Investigate both spring compression and extension
- ▶ Amount of energy stored in a spring

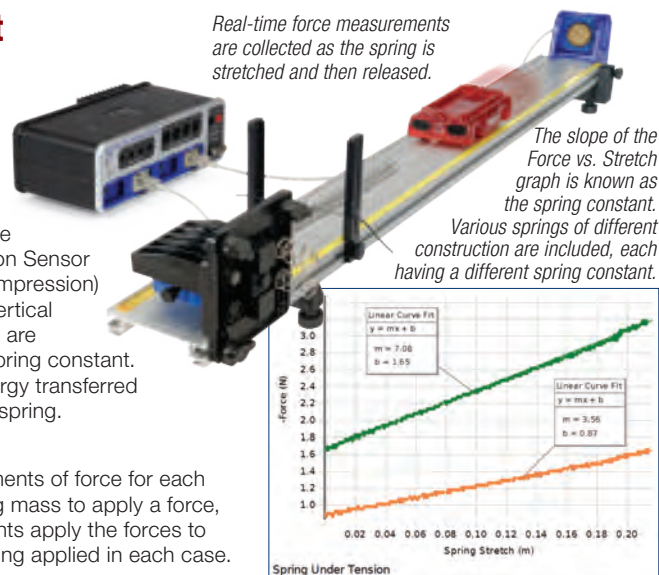
In this experiment, students use a High Resolution Force Sensor to measure the force exerted to either compress or extend various springs, and a Motion Sensor to measure position and speed. Students create a Force vs. Stretch (or Compression) graph. The slope of this graph is known as the spring constant, while the vertical intercept is the initial loading force. Various springs of different construction are included, so students can better understand the physical meaning of the spring constant. The spring is then compressed (or stretched) and released. The kinetic energy transferred to a PAScar is measured and compared to the potential energy lost by the spring.

PASCO Advantage:

The High Resolution Force Sensor allows students to take direct measurements of force for each compression or elongation of the spring. This is superior to using a hanging mass to apply a force, since students don't have to convert from mass to force. In addition, students apply the forces to the springs, giving them a better kinesthetic feel for the amount of force being applied in each case. Energy changes are easily measured and very visual.

Includes:

- PASPORT Motion Sensor PS-2103A
- IDS Spring Kit ME-8999
- PASPORT High Resolution Force Sensor PS-2189
- Force Sensor Track Bracket ME-6622
- Spring Cart Launcher ME-6843
- Elastic Bumper ME-8998
- Braided Physics String SE-8050



Real-time force measurements are collected as the spring is stretched and then released.

The slope of the Force vs. Stretch graph is known as the spring constant. Various springs of different construction are included, each having a different spring constant.

Download This Experiment

The FREE experiment files include a pdf of the student instructions and a PASCO Capstone™ workbook file. Download this experiment at pasco.com/CapstoneExperiments.

Order Information

Hooke's Law and Spring Potential Experiment EX-5504A

Required:

550 or 850 Universal Interface* pp. 20-23
 PASCO Capstone Software pp. 8-11

* This experiment can be performed using the 550 or 850 Universal Interface or any PASPORT interface with two ports.

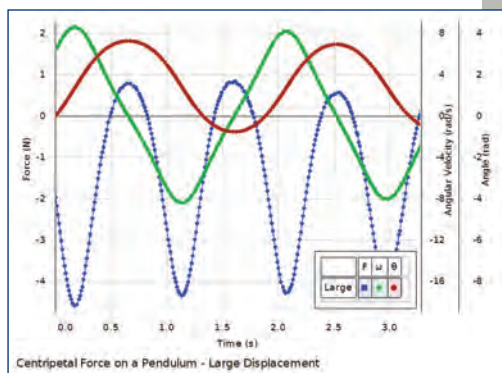
Centripetal Force on a Pendulum Experiment

EX-5605

Concepts:

- ▶ Centripetal force
- ▶ Angular velocity
- ▶ Periodic motion

In this experiment, students explore the relationship between mass, radius of rotation, angular velocity, and centripetal force. The force and angular velocity are continuously measured, allowing students to see not only peak values, but also how these change during the entire motion of the pendulum. Students also explore sources of error and magnitude of error.



The force, position, and velocity can be monitored for the entire range of motion. Note that the position and velocity are not sinusoidal for this large amplitude pendulum.



Includes:

- Wireless Force Acceleration Sensor PS-3202
- Wireless Rotary Motion Sensor PS-3220
- Centripetal Force Pendulum ME-9821
- Aluminum Table Clamp ME-8995
- 45 cm Stainless Steel Rod ME-8736

Download This Experiment

The FREE experiment files include a pdf of the student instructions and a PASCO Capstone™ workbook file. Download this experiment at pasco.com/CapstoneExperiments.

Order Information

Centripetal Force on a Pendulum Experiment..... EX-5605

Required:

PASCO Capstone Software pp. 8-11
Balance or Scale..... p. 212

View the 550 or 850 Universal Interface-compatible version of this experiment (EX-5505A) online at pasco.com/capstoneexperiments

Centripetal Force Experiment

EX-5506

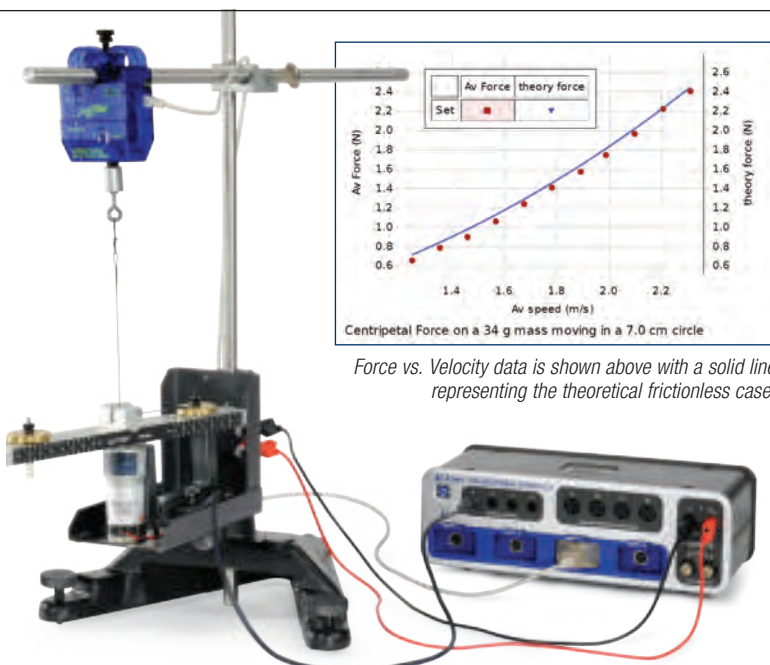
Concepts:

- ▶ Centripetal force depends on radius, mass, and speed

Students explore the relationship between mass, radius of rotation, tangential speed, and centripetal force. By continuously measuring the force as the speed is varied, students clearly see the effect of speed on the centripetal force. The effect of changing the mass or radius is also investigated.

Includes:

- Centripetal Force Apparatus ME-8088
- PASPORT High Resolution Force Sensor PS-2189
- Photogate Head ME-9498A
- Large Rod Base ME-8735
- 90 cm Stainless Steel Rod ME-8738
- Multi-Clamp ME-9507
- 45 cm Stainless Steel Rod ME-8736
- Banana Plug Cord-Red (5 pack) SE-9750



Force vs. Velocity data is shown above with a solid line representing the theoretical frictionless case.

Download This Experiment

The FREE experiment files include a pdf of the student instructions and a PASCO Capstone™ workbook file. Download this experiment at pasco.com/CapstoneExperiments.

Order Information

Centripetal Force Experiment..... EX-5506

Required:

550 or 850 Universal Interface* pp. 20-23
PASCO Capstone Software..... pp. 8-11

Mechanics

Materials Stress-Strain (Wireless) Experiment

EX-5615

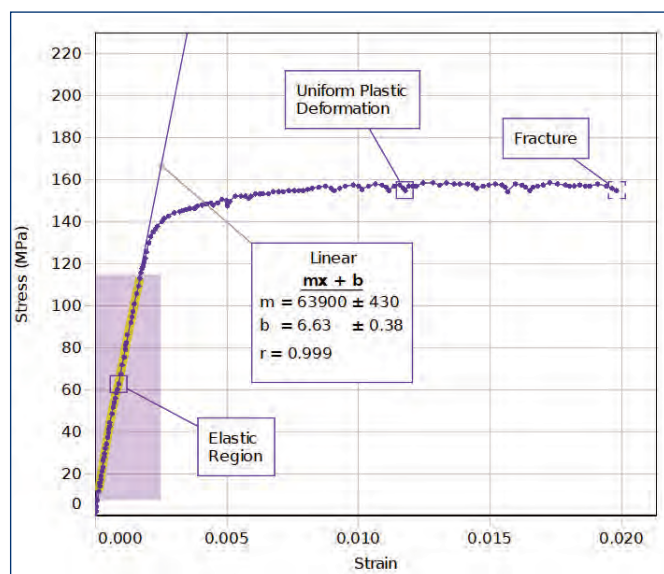
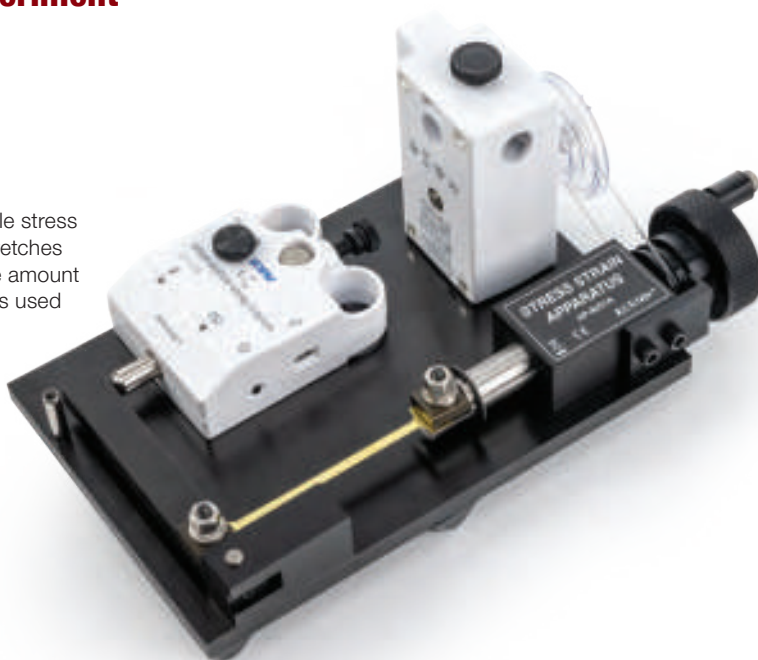
Concepts:

- Stress
- Strain
- Young's Modulus

The objective of this lab is to find the relationship between tensile stress and strain for various materials. The Stress-Strain Apparatus stretches (and in some cases breaks) a test coupon while it measures the amount of stretch and force experienced by the test coupon. Software is used to generate a plot of stress versus strain, which allows Young's Modulus, the elastic region, the plastic region, the yield point, and the break point to be ascertained.

Since the Stress-Strain Apparatus shows the entire stress versus strain curve, it is possible to measure a wide range of material properties including:

- Young's Modulus
- Yield strength
- Tensile strength
- Ductility
- Toughness
- Students can also compare the different curve shapes produced by various materials. PASCO Capstone software allows students to determine Young's Modulus by measuring the slope of the initial straight line (the elastic region) and to determine the toughness by integrating under the curve.



How It Works:

Tension is applied to the sample by turning the knob by hand until the sample breaks. The force used to stretch the sample is measured using a Force Sensor connected via USB or Bluetooth. A metal lever provides a five-to-one mechanical advantage, increasing the maximum force that the sensor can read to 250 N.

The stress is calculated using Capstone by taking the force over the cross-sectional area. No adjustment is made for any change in the cross-sectional area during stretching.

The change in length of the sample is measured using a Rotary Motion Sensor. The resolution is 0.007 mm. The strain is calculated using Capstone by dividing the change in length by the original length.

Includes:

- | | |
|--|---------|
| • Stress/Strain Apparatus | |
| • Wireless Force Acceleration Sensor | PS-3202 |
| • Wireless Rotary Motion Sensor | PS-3220 |
| • Stress-Strain Apparatus Coupons, Plastic | AP-8222 |
| • Stress-Strain Apparatus Coupons, Metal | AP-8223 |
| • Digital Calipers | SE-8710 |

Order Information

Materials Stress-Strain (Wireless) Experiment..... EX-5615

Required:

PASCO Capstone Software pp. 8-11

Download This Experiment

The FREE experiment files include a pdf of the student instructions and a PASCO Capstone™ workbook file. Download this experiment at pasco.com/CapstoneExperiments.

View the 550 or 850 Universal Interface-compatible version of this experiment (EX-5515B) online at pasco.com/capstoneexperiments

Impulse Experiment

EX-5509B

Features:

- Designed for use with the Smart Cart

Concepts:

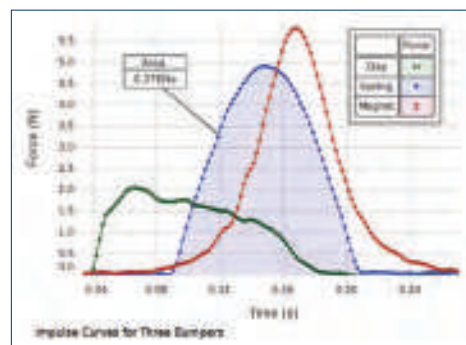
- **Impulse:** Change in momentum
- **Impulse:** Area under a Force vs. Time curve
- Different shaped force curves for elastic and inelastic collisions

In this experiment, the impulse on a cart is determined in two ways: by measuring the change in velocity and by finding the area under a Force vs. Time curve.

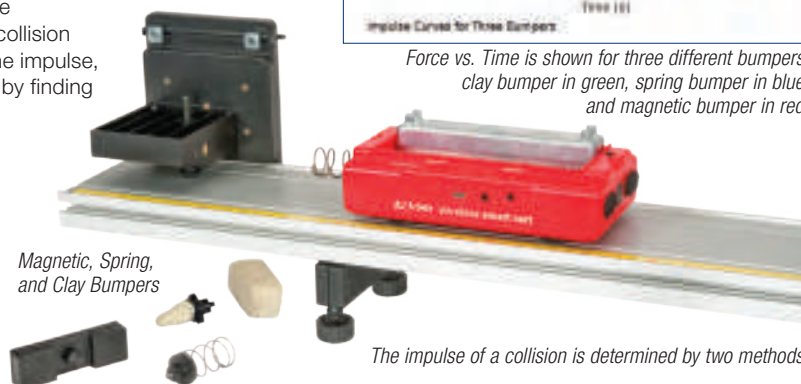
A Smart Cart runs down a slightly inclined track with its Force Sensor equipped with either a clay bumper, spring bumper, or magnetic bumper. The cart collides with the endstop. To determine the change in momentum (impulse), the velocities before and after the collision are recorded using the Smart Cart's encoder. To confirm the impulse, the force vs. time is plotted, and the impulse is determined by finding the area under the curve.

Includes:

- | | |
|------------------------------------|----------|
| • Force Sensor Track Bracket | ME-6622 |
| • PAScar Cart Mass (Set of 2) | ME-6757A |
| • Smart Cart (Red) | ME-1240 |
| • Dynamics Track End Stop (2 Pack) | ME-8971 |
| • Dynamics Track Feet (Pair) | ME-8972 |
| • 1.2 m Aluminum Dynamics Track | ME-9493 |
| • Smart Cart Rod Stand Adapter | ME-1244 |



Force vs. Time is shown for three different bumpers: clay bumper in green, spring bumper in blue, and magnetic bumper in red.



The impulse of a collision is determined by two methods.

Order Information

Impulse Experiment	EX-5509B
Required:	
Bluetooth 4.0 enabled computer	
PASCO Capstone Software	pp. 8-11
Balance or Scale	p. 212

Download This Experiment

The FREE experiment files include a pdf of the student instructions and a PASCO Capstone™ workbook file. Download this experiment at pasco.com/CapstoneExperiments.

Conservation of Momentum Experiment

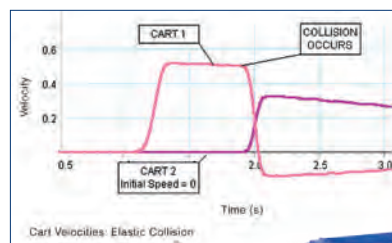
EX-5510C

Concepts:

- Conservation of momentum in elastic and inelastic collisions
- Kinetic energy is not conserved in inelastic collisions
- Kinetic energy can be temporarily stored as magnetic potential energy during elastic collisions using magnetic bumpers

The total momentum and total energy of carts undergoing elastic and inelastic collisions are measured. The values before and after the collisions are compared to verify that momentum is conserved in all collisions, while energy is only conserved in elastic collisions.

Elastic and inelastic collisions are performed with two dynamics carts of different masses. Magnetic bumpers are used in the elastic collision and Velcro bumpers are used in the completely inelastic collision. In both cases, momentum is conserved. Cart velocities are recorded using the encoders inside the Smart Carts. A real-time graph of Velocity vs. Time is obtained for each cart, clearly showing when the collision occurred. This enables the student to determine the cart velocities immediately before and after the collision.



Features:

- Designed for use with 2 Smart Carts

A real-time graph of Velocity vs. Time is obtained for each cart, clearly showing when the elastic collision occurred.



Includes:

- | | |
|------------------------------------|----------|
| • PAScar Cart Mass (set of 2) | ME-6757A |
| • Smart Cart (Red) | ME-1240 |
| • Smart Cart (Blue) | ME-1241 |
| • Dynamics Track End Stop (2 Pack) | ME-8971 |
| • Dynamics Track Feet (Pair) | ME-8972 |
| • 1.2 m Aluminum Dynamics Track | ME-9493 |
| • Smart Cart Rod Stand Adapter | ME-1244 |

Order Information

Conservation of Momentum Experiment	EX-5510C
Required:	
Bluetooth 4.0 enabled computer	
PASCO Capstone Software	pp. 8-11
Balance or Scale	p. 212

Download This Experiment

The FREE experiment files include a pdf of the student instructions and a PASCO Capstone™ workbook file. Download this experiment at pasco.com/CapstoneExperiments.

Mechanics

Ballistic Pendulum Experiment

EX-5611

Concepts:

- Conservation of momentum
- Conservation of energy

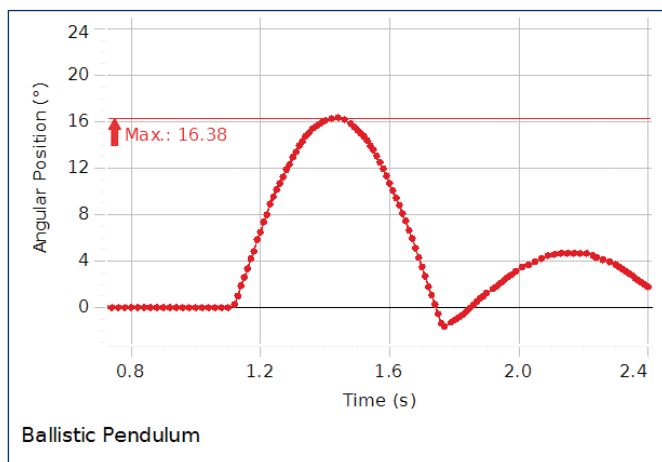
PASCO's Wireless Rotary Motion Sensor is the heart of this modern approach to a classic physics experiment. The Mini Launcher (ME-6825B) fires a steel ball into the foam catcher of the Ballistic Pendulum Accessory (ME-6829) mounted on the Wireless Rotary Motion Sensor. The Wireless Rotary Motion Sensor measures the angular displacement of the pendulum and plots it in real-time in PASCO Capstone.

There is no need to catch the pendulum at its maximum height because the angle is continuously measured. Students can use the analysis tools in PASCO Capstone, to find the maximum angle.

Using Conservation of Momentum and Conservation of Energy, students can determine the initial speed of the ball as it leaves the projectile launcher. The initial speed of the ball is confirmed by using two photogates to time the flight of the ball for a short distance.



The ball is shot into a foam catcher at the end of a pendulum. The pendulum is mounted on a Rotary Motion Sensor to record the entire swing.



This graph of the angle of the pendulum vs. time is plotted in real time in PASCO Capstone. The maximum angle is displayed on the graph.

Includes:

- | | |
|-------------------------------------|----------|
| • Wireless Rotary Motion Sensor | PS-3220 |
| • Mini Launcher | ME-6825B |
| • Wireless Smart Gate | PS-3225 |
| • Photogate Mounting Bracket | ME-6821A |
| • Mini Ballistic Pendulum Accessory | ME-6829 |
| • Large C Clamp | |
| • 45 cm Stainless Steel Rod | ME-8736 |

Download This Experiment

The FREE experiment files include a pdf of the student instructions and a PASCO Capstone™ workbook file. Download this experiment at pasco.com/CapstoneExperiments.

Order Information

Ballistic Pendulum Experiment..... EX-5611
 Required:
 PASCO Capstone Software..... pp. 8-11

View the 550 or 850 Universal Interface-compatible version of this experiment (EX-5511A) online at pasco.com/capstoneexperiments

Conservation of Energy Experiment

EX-9935

Concepts:

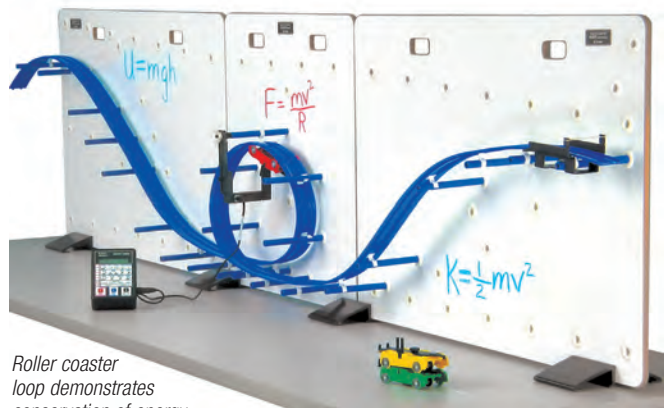
- Conservation of energy
- Centripetal acceleration
- Apparent weight

In this experiment, the Law of Conservation of Energy is verified by measuring the potential and kinetic energies of a car traveling over hills and loops on a curved track.

A car is started from rest on a variety of tracks (hills, valleys, loops, straight track). The speed of the car is measured at various points along the track using a photogate connected to a Smart Timer.

The potential energy is calculated from the measured height and the kinetic energy is calculated from the speed. The total energy is calculated for two points on the track and compared.

The height from which the car must be released from rest to just make it over the loop can be predicted from conservation of energy and the centripetal acceleration. Then the prediction can be tested on the roller coaster. If the car is released from the top of the hill and easily makes it over the top of the loop, the speed of the car can be measured at the top of the loop and the centripetal acceleration as well as the apparent weight (normal force) on the car can be calculated.



Roller coaster loop demonstrates conservation of energy.

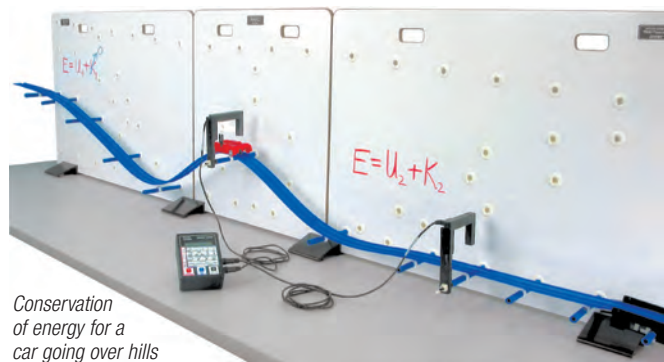
PASCO Advantage:

The Roller Coaster can be configured in many ways. The whiteboard background is convenient for writing calculations or making marks for measuring heights. The PASCO Roller Coaster differs from conventional roller coaster toys in three ways:

- Speed and height of the Roller Coaster car can be easily measured
- Loss of energy due to friction is generally only about 5%
- Cars will withstand repeated drops to the floor

Includes:

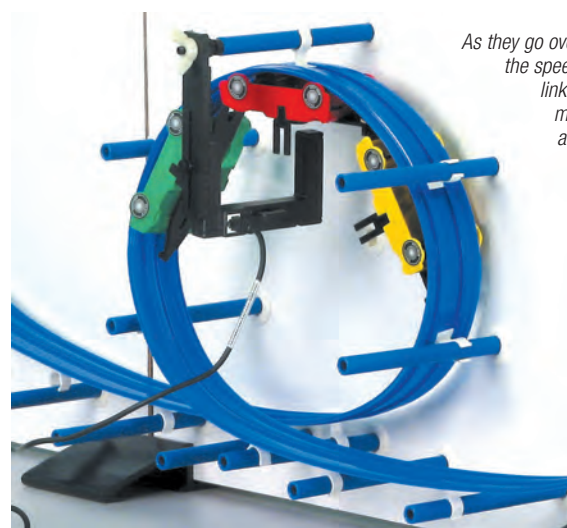
- Roller Coaster Complete System ME-9812
- Photogate Head (2) ME-9498A
- Smart Timer ME-8930



Conservation of energy for a car going over hills



Conservation of energy shows that the final speeds of these two cars are the same even though the red car takes much less time than the yellow car to reach the end of the track.



As they go over the loop, the speeds of three linked cars are measured by a photogate.

Download This Experiment

Search for EX-9935 at pasco.com

Order Information

Conservation of Energy Experiment.....EX-9935

Mechanics

Conservation of Energy II Experiment

EX-5612

Concepts:

- Potential energy of a falling ball
- Kinetic energy of a falling ball
- Use different size balls to change friction

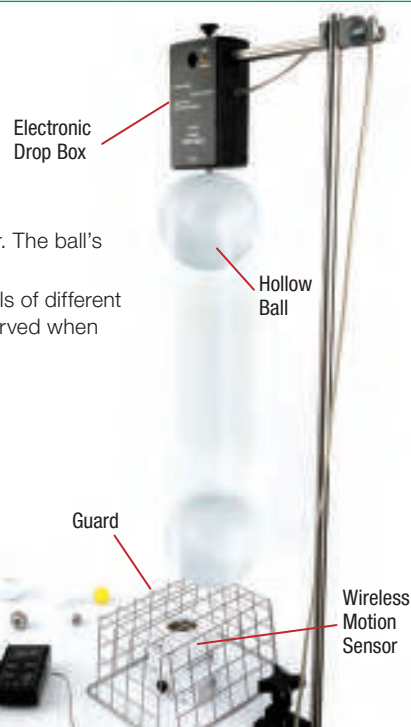
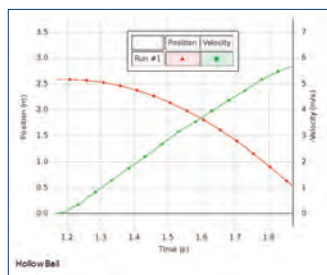
A ball is dropped from rest and its height and speed are recorded using a Wireless Motion Sensor. The ball's potential energy and kinetic energy are calculated at various points during the ball's fall.

The total energy of the ball is examined throughout the fall to determine if there is any change. Balls of different sizes are used to vary the amount of air friction, so that students can see that energy is not conserved when friction is appreciable.

Includes:

- Wireless Motion Sensor PS-3219
- Discover Freefall System ME-9889
- Large Rod Base ME-8735
- 120 cm Stainless Steel Rod ME-8741
- Multi-Clamp ME-9507
- 45 cm Stainless Steel Rod ME-8736
- Motion Sensor Guard SE-7256

As the ball falls, its height and speed are recorded and displayed in PASCO Capstone software.



Order Information

Conservation of Energy II Experiment EX-5612
Required:
PASCO Capstone Software pp. 8-11

View the 550 or 850 Universal Interface-compatible version of this experiment (EX-5512) online at pasco.com/capstoneexperiments

Download This Experiment

The FREE experiment files include a pdf of the student instructions and a PASCO Capstone™ workbook file. Download this experiment at pasco.com/CapstoneExperiments.

Work Energy Theorem Experiment

EX-5513A

Concepts:

- Kinetic energy
- Potential energy
- Work energy theorem
- Conservation of mechanical energy

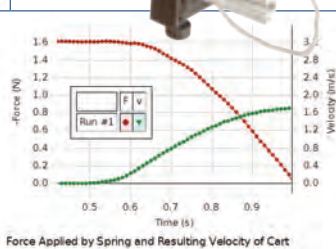
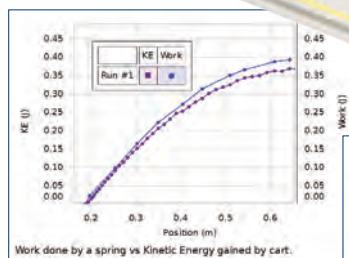
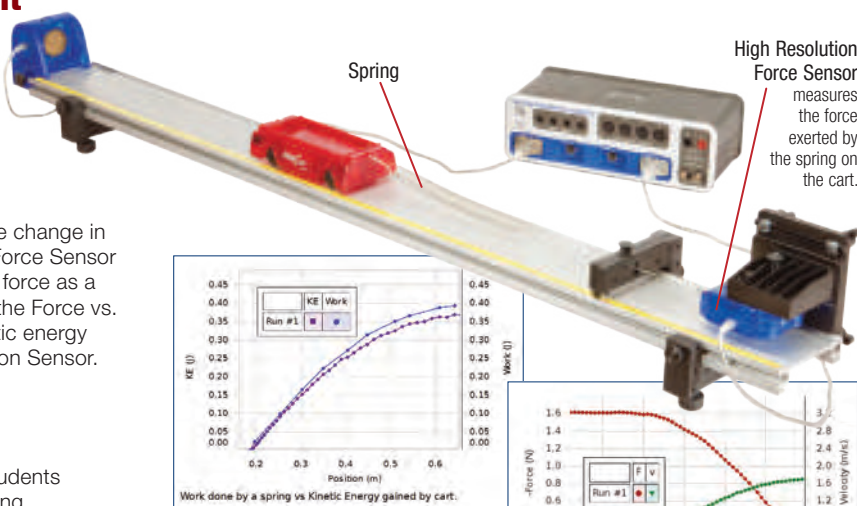
The total work done on an object is compared with the change in kinetic energy of the object. Using a High Resolution Force Sensor and a Motion Sensor, students record and display the force as a function of position. The work done is the area under the Force vs. Position plot. At any point during the experiment, kinetic energy is calculated from the velocity measured with the Motion Sensor. Students explore the meaning of dissipative forces.

PASCO Advantage:

Instead of just focusing on the end points, real-time measurements of force, position, and velocity allow students to continuously examine the work done and the resulting kinetic energy of the cart during its entire trip down the track.

Includes:

- PASPORT High Resolution Force Sensor PS-2189
- PASPORT Motion Sensor PS-2103A
- Force Sensor Track Bracket ME-6622
- IDS Spring Kit ME-8999
- Braided Physics String SE-8050



Work done by friction and ignoring the rotational kinetic energy of the wheels cause the cart kinetic energy to be approximately 5% lower.

Order Information

Work Energy Theorem Experiment EX-5513A
Required:
550 or 850 Universal Interface* pp. 20-23
PASCO Capstone Software pp. 8-11
Balance or Scale p. 212
* This experiment can be performed using the 550 or 850 Universal Interface or any PASPORT interface with two ports.

Cavendish Experiment

EX-5550A

Concepts:

- ▶ Measure the Universal Gravitational Constant in less than three hours!
- ▶ Recreate Cavendish's historical experiment
- ▶ Uses PASCO Capstone Video Analysis

The attraction between a pair of small tungsten spheres and a pair of larger spheres is measured by the torsion of a beryllium ribbon. The large spheres are placed close to the small spheres and allowed to equilibrate.

A laser is reflected from a mirror on the beryllium ribbon and shown on a screen or wall. The large spheres are then rotated through an angle to produce torque on the ribbon. The mirror rotates with the ribbon, so the laser reflection on the screen or wall is displaced. The displacement of the laser reflection is measured to find "G".

PASCO Advantage:

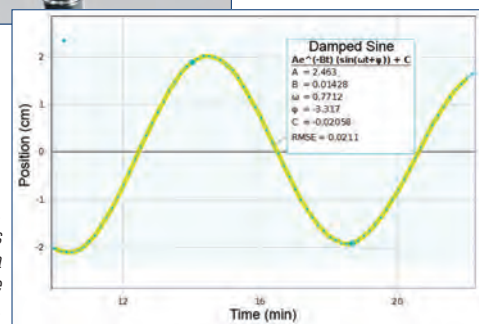
For the first time, the measurement of G using the Cavendish Balance can actually be performed in a three-hour lower division physics laboratory! Data is collected using a webcam to video two periods of the oscillation for both ball positions in less than 45 minutes. The video data may then be transferred to lab groups for analysis using the video analysis features within PASCO Capstone. Fitting a damped sine curve to the video data allows an extremely precise determination of both the period of oscillation and the position of the final equilibrium. When analysis of small effects inherent in the method is included, an accuracy of better than 2% is possible



This is a screenshot of the video analysis points (red plus signs) in PASCO Capstone.



The USB Camera Microscope (not included) records the oscillation of the laser beam.



In PASCO Capstone, a damped sine fit is applied to the data to determine the equilibrium point.

Includes:

- Cavendish Gravitational Torsion Balance AP-8215A
- X-Y Adjustable Diode Laser OS-8526A
- Polarizer Set OS-8473
- Large Rod Base ME-8735
- Stainless Steel Rod, 45 cm ME-8736
- Small A-Base with Leveling Feet ME-8989
- Flex Rod ME-8978A
- Aluminum Table Clamp ME-8995

NOTE: No interface is required.

Download This Experiment

The FREE experiment files include a pdf of the student instructions and a PASCO Capstone™ workbook file. Download this experiment at pasco.com/CapstoneExperiments.

Order Information

Cavendish ExperimentEX-5550A
 Required:
 PASCO Capstone Software pp. 8-11
 USB Camera Microscope
 Transparent Ruler and Meter Stick

Mechanics

Archimedes' Principle Experiment

EX-9909

Concepts:

- Archimedes' Principle
- Density
- Buoyant force

Archimedes' Principle states that the buoyant force on a submerged object is equal to the weight of the fluid that is displaced by the object.

In this experiment, the buoyant force on several objects is measured by weighing the water displaced by a submerged object. The buoyant force is also determined by measuring the difference between the object's weight in air and its apparent weight in water.

Some of the objects have the same density, some have the same volume, and some have the same mass. The density of each object is measured and the dependence of the buoyant force on density, mass, and volume is explored.

PASCO Advantage:

The provided objects have related volumes, masses, and densities to demonstrate that only the volume of water displaced affects the buoyant force.



The buoyant force is measured by weighing the water displaced by the object.



The mass and volume are measured to determine the dependence of the buoyant force on mass, volume, and density.

Includes:

- Density Set ME-8569A
- Overflow Can SE-8568
- Large Rod Base ME-8735
- 45 cm Stainless Steel Rod ME-8736
- Braided Physics String SE-8050
- Ohaus Triple-Beam Balance (with Tare) SE-8707
- Stainless Steel Calipers SE-8710
- 1000 ml Beaker
- 100 ml Beaker
- 50 ml Graduated Cylinder
- Archimedes' Principle Experiment Manual

Download This Experiment

Search for EX-9909 at pasco.com

Order Information

Archimedes' Principle Experiment.....EX-9909
(No interface required.)

Rotational Inertia Experiment

EX-5616

Concepts:

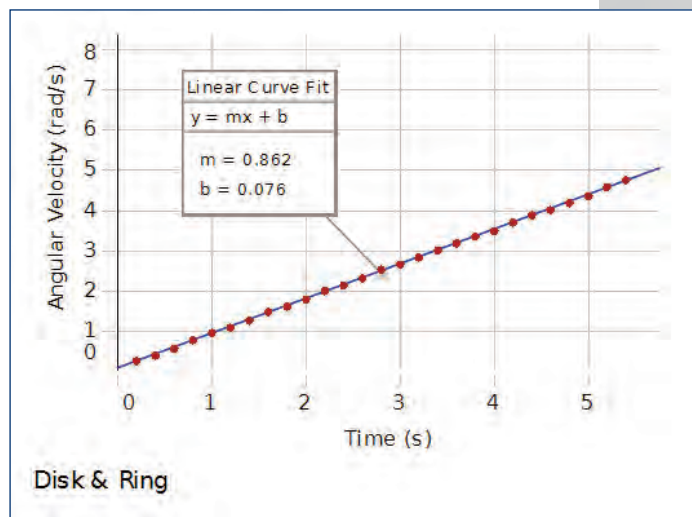
- ▶ Rotational inertia of a ring and disk
- ▶ Torque

In this experiment, the rotational inertias of a ring and a disk are determined by applying a torque to the object and measuring the resulting angular acceleration.

A known torque is applied to the pulley on the Wireless Rotary Motion Sensor, causing a disk and ring to rotate. The resulting angular acceleration is measured using the slope of a graph of Angular Velocity vs. Time. The rotational inertia of the disk and ring combination is calculated from the torque and the angular acceleration. The procedure is repeated for the disk alone to find the rotational inertias of the ring and disk separately.

PASCO Advantage:

Friction can be neglected in this compact setup. The Wireless Rotary Motion Sensor is a versatile tool that can be used in a variety of other experiments.



The rotational inertia of the ring and disk is calculated from the angular acceleration, which can be obtained from the slope of the Angular Velocity vs. Time graph.

Includes:

- Large Rod Base ME-8735
- 90 cm Stainless Steel Rod ME-8738
- Rotational Inertia Accessory ME-3420
- Mass and Hanger Set ME-8979
- Wireless Rotary Motion Sensor PS-3220

Download This Experiment

The FREE experiment files include a pdf of the student instructions and a PASCO Capstone™ workbook file. Download this experiment at pasco.com/CapstoneExperiments.



Order Information

Rotational Inertia Experiment	EX-5616
Required:	
PASCO Capstone Software	pp. 8-11
Balance or Scale	p. 212
Digital Calipers	SE-8710 p. 208

View the 550 or 850 Universal Interface-compatible version of this experiment (EX-5516B) online at pasco.com/capstoneexperiments

Rotation

Static Equilibrium

EX-5564

Concepts:

- ▶ The sum of the torques is zero.
- ▶ The sum of the forces is zero.
- ▶ The force of the weight of the meter stick acts at its center of mass.

Wireless
Force Sensor
measures tension.

There are two requirements for an object to be in static equilibrium:

- ▶ The sum of the torques is zero.
- ▶ The sum of the forces is zero.

An object is hung from a horizontal meter stick, which is suspended from a vertical rod by a string. Summing the torques, the equation is solved for the tension in the string. The tension in the string is also measured directly with the Wireless Force Sensor.

The force at the pivot is determined by summing the forces.

Pivot

10 g Mass Hanger

PASCO Advantage:

The PASCO Pivot has a built-in level to make it easy to tell when the meter stick is horizontal. The Wireless Force Sensor gives a direct reading of the tension in the string.

Includes:

- | | |
|---------------------------------------|---------|
| • Meter Stick Torque Set | ME-7033 |
| • Wireless Force Acceleration Sensor | PS-3202 |
| • Hooked Mass Set | SE-8759 |
| • Large Table Clamp | ME-9472 |
| • 90 cm Stainless Steel Rod | ME-8738 |
| • Stainless Steel Rod, 25 cm Threaded | ME-8988 |
| • Multi-Clamp | ME-9507 |

Order Information

Static Equilibrium.....EX-5564

Required:

PASCO Capstone Software.....pp. 8-11
(No interface required.)

Download This Experiment

The FREE experiment files include a pdf of the student instructions and a PASCO Capstone™ workbook file. Download this experiment at pasco.com/CapstoneExperiments.

Conservation of Angular Momentum Experiment

EX-5517C

Concepts:

- Conservation of angular momentum during collisions
- Easy determination of before and after points
- Calculation of energy lost during collision

Based on the Rotary Motion Sensor, this system makes studies of angular momentum conservation quick and easy. The angular velocity of the spinning disk is graphed in real time as a non-rotating ring is dropped onto it.

PASCO Advantage:

It is easy to measure the rotational speeds just before and after the collision since the entire collision is visible in the graph.

The rotational inertias of the ring and disk are calculated using the mass and dimensions of each. Then the total angular momentum before the collision is compared to the total angular momentum after the collision to show that it does not change.

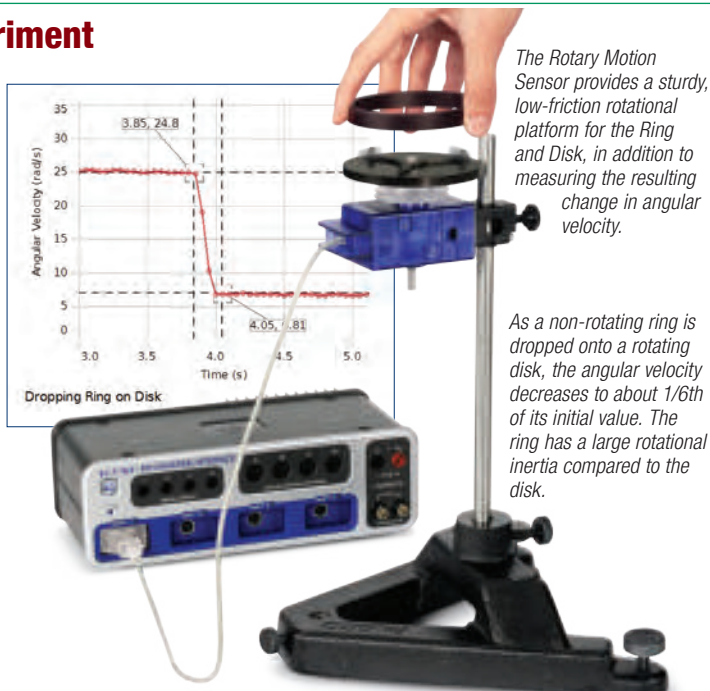
The total kinetic energy before and after the collision is calculated to show the amount of energy lost during the inelastic collision.

Includes:

- | | |
|--------------------------------|----------|
| • PASPORT Rotary Motion Sensor | PS-2120A |
| • Mini Rotational Accessory | CI-6691 |
| • Stainless Steel Calipers | SE-8710 |
| • Large Rod Base | ME-8735 |
| • 45 cm Stainless Steel Rod | ME-8736 |

Download This Experiment

The FREE experiment files include a pdf of the student instructions and a PASCO Capstone™ workbook file. Download this experiment at pasco.com/CapstoneExperiments.



Order Information

Conservation of Angular Momentum Experiment..... EX-5517C

Required:

550 or 850 Universal Interface* pp. 20-23

PASCO Capstone Software..... pp. 8-11

* This experiment can be performed using the 550 or 850 Universal Interface or AirLink.

Physical Pendulum Experiment

EX-5618

Concepts:

- Parallel Axis Theorem
- Period of a physical pendulum
- Computer modeling of a system
- Rotational inertia

In this experiment, the period of a physical pendulum, a narrow bar, is determined as a function of the distance of the pivot from the center of mass. A computer model of the system is developed, which allows the student to vary the physical parameters of the model (gravity, length, c.m. position) to match the data. This makes it possible to obtain values for the physical parameters without direct measurement.

A second experiment verifies the parallel axis theorem.

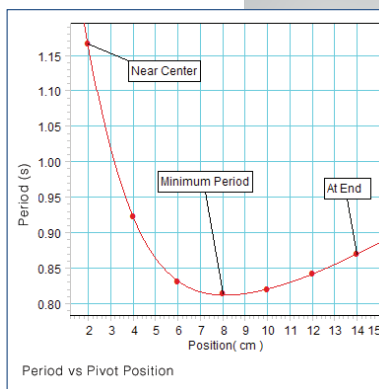
It also uses superposition to find the rotational inertia of a disk with an off axis circular hole.

Includes:

- | | |
|---------------------------------|----------|
| • Large Rod Base | ME-8735 |
| • 45 cm Stainless Steel Rod | ME-8736 |
| • Physical Pendulum Set | ME-9833 |
| • Wireless Rotary Motion Sensor | PS-3220 |
| • Super Pulley with Clamp | ME-9448B |

Download This Experiment

The FREE experiment files include a pdf of the student instructions and a PASCO Capstone™ workbook file. Download this experiment at pasco.com/CapstoneExperiments.



The Pendulum Bar has holes spaced at 2 cm intervals. A graph of Oscillation Period vs. Pivot Hole Position shows that there is a unique placement that gives a minimum period. This location can be verified using calculus.



Order Information

Physical Pendulum Experiment..... EX-5618

Required:

PASCO Capstone Software..... pp. 8-11

View the 550 or 850 Universal Interface-compatible version of this experiment (EX-5518A) online at pasco.com/capstoneexperiments

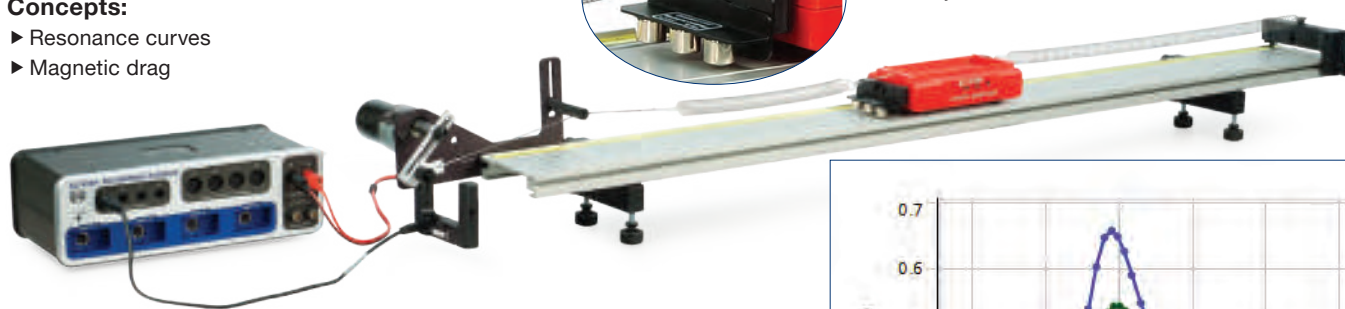
Oscillations

Driven Damped Cart Oscillations

EX-5551A

Concepts:

- ▶ Resonance curves
- ▶ Magnetic drag



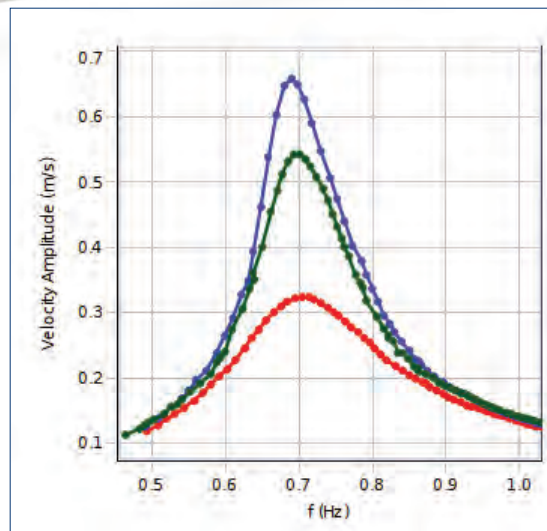
Magnets induce currents in the aluminum track and cause a drag force that is proportional to the cart velocity.

The oscillator consists of a Smart Cart attached to two springs. The damping is provided by magnets mounted on the Smart Cart that cause eddy currents in the aluminum track. The amplitude of the oscillation is plotted vs. the driving frequency for different amounts of magnetic damping. Increased damping is provided by moving adjustable magnets closer to the aluminum track.

$$\frac{d^2x}{dt^2} + \left(\frac{b}{m}\right) \frac{dx}{dt} + \left(\frac{k}{m}\right)x = F_0 \cos(\omega t)$$

$$x = \frac{F_0/m}{\sqrt{(\omega^2 - \omega_0^2)^2 + (b/m)^2 \omega^2}} \cos(\omega t - \phi)$$

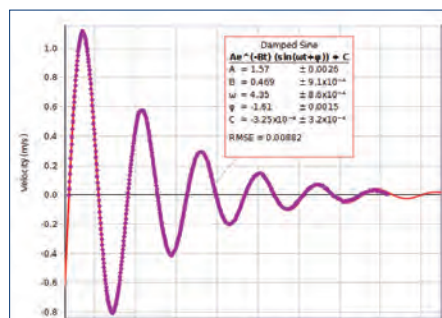
$$\omega = \sqrt{\frac{k}{m} - \frac{b^2}{4m^2}}$$



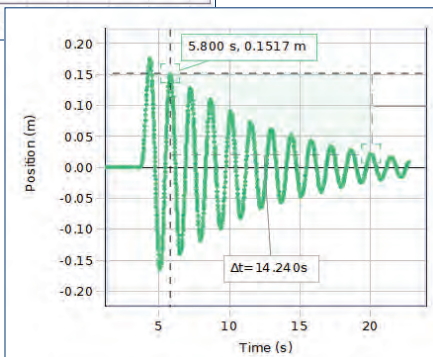
The amplitude of the cart's velocity is plotted vs. the driving frequency. The amount of drag is varied by changing the distance between the magnets and the track.

PASCO Advantage:

The Smart Cart wirelessly measures the position and velocity of the cart as well as the magnetic drag, since the magnetic drag bumper is attached to the Smart Cart's force sensor.



In PASCO Capstone, a damped sine wave curve fit is applied to the data to determine the spring constant, period, and damping coefficient.



The period can be directly measured to determine the resonant frequency.

Includes:

- Smart Cart (red) ME-1240
- Mechanical Oscillator/Driver ME-8750
- Dynamics Cart Magnetic Damping ME-6828
- IDS Spring Kit ME-8999
- Photogate Head ME-9498A
- PAScar Cart Mass (set of 2) ME-6757A
- 1.2 m Aluminum Dynamics Track ME-9493
- Dynamics Track End Stop (2 pack) ME-8971
- Dynamics Track Feet (pair) ME-8972
- Braided Physics String SE-8050
- Smart Cart Rod Stand Adapter ME-1244

Download This Experiment

The FREE experiment files include a pdf of the student instructions and a PASCO Capstone™ workbook file. Download this experiment at pasco.com/CapstoneExperiments.

Order Information

Driven Damped Cart Oscillations..... EX-5551A

Required:

Ohaus Triple-Beam Balance (with Tare)..... SE-8707

850 Universal Interface..... UI-5000 pp. 20-22

PASCO Capstone Software..... pp. 8-11

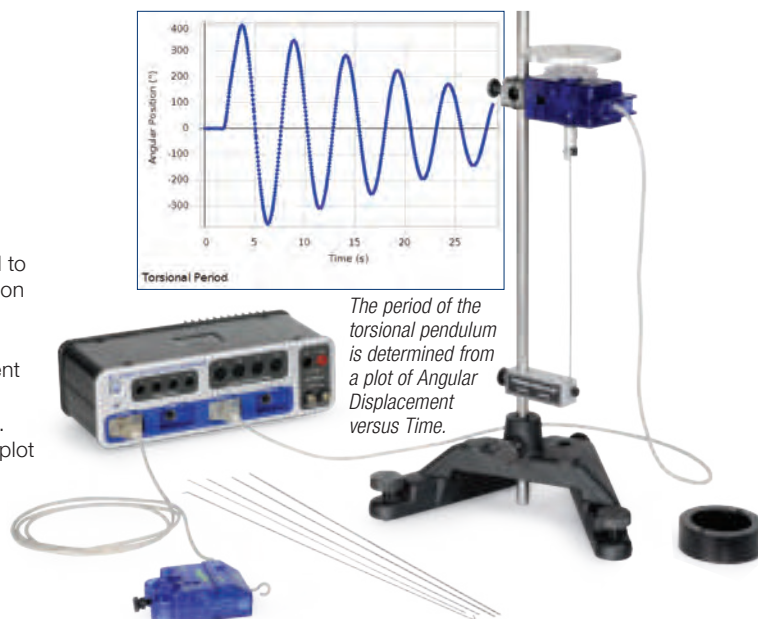
Torsional Pendulum

EX-5521A

Concepts:

- Period of a torsional pendulum
- Rotational inertias of a disk, ring, and point masses
- Torque
- Torsional spring constant

The period of a Torsional Pendulum is measured and compared to the theoretical value. The Torsional Pendulum consists of a torsion wire attached to a Rotary Motion Sensor with an object (a disk, ring, or rod with point masses) mounted on top of it. The period of oscillation is measured from a plot of the Angular Displacement versus Time. To calculate the theoretical period, the rotational inertia is determined by measuring the dimensions of the object. The torsional spring constant is determined from the slope of a plot of Force versus Angular Displacement.



Includes

- | | |
|--|----------|
| • Rotational Inertia Accessory | ME-3420 |
| • Torsion Pendulum Accessory | ME-6694 |
| • Large Rod Base | ME-8735 |
| • 60 cm Long Stainless Steel Rod | ME-8977 |
| • PASPORT Rotary Motion Sensor | PS-2120A |
| • PASPORT High-Resolution Force Sensor | PS-2189 |

Download This Experiment

The FREE experiment files include a pdf of the student instructions and a PASCO Capstone™ workbook file. Download this experiment at pasco.com/CapstoneExperiments.

Order Information

Torsional Pendulum EX-5521A
 Required:
 550 or 850 Universal Interface* pp. 20-23
 PASCO Capstone Software pp. 8-11
 * This experiment can be performed using the 550 or 850 Universal Interface or any PASPORT interface with two ports.

Coupled Pendulum

EX-5563

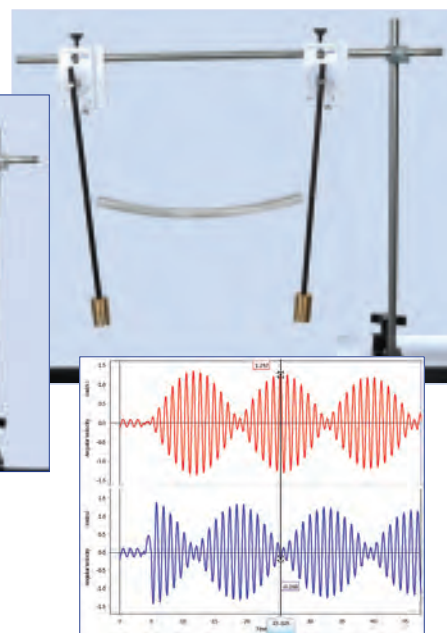
Concepts:

- Resonant Modes of Oscillation
- Period of Transfer of Oscillation Energy between Coupled Pendula

Two pendula are coupled by a spring. This system has two natural modes:

- The two pendula swing in sync.
- The two pendula swing opposite to each other.

When one of the pendula is held at rest and the other is set oscillating, the energy of the oscillating pendulum is transferred to the other pendulum by the spring. The period of the energy transfer can be predicted and verified by experiment.



Includes:

- | | |
|---------------------------------------|-------------|
| • Wireless Rotary Motion Sensor | PS-3220 (2) |
| • Pendulum Accessory | ME-8969 (2) |
| • Longitudinal Wave Spring | WA-9401 |
| • Large Table Clamp | ME-9472 |
| • Stainless Steel Rod, 60 cm Threaded | ME-8977 (2) |
| • Multi-Clamp | ME-9507 |

Download This Experiment

The FREE experiment files include a pdf of the student instructions and a PASCO Capstone™ workbook file. Download this experiment at pasco.com/CapstoneExperiments.

Order Information

Coupled Pendulum EX-5563
 Required:
 PASCO Capstone Software pp. 8-11
 (No interface required.)

Oscillations

Chaos Experiment

EX-5523A

Concepts:

- ▶ Nonlinear oscillator
- ▶ Chaotic motion
- ▶ Phase space
- ▶ Poincare plot

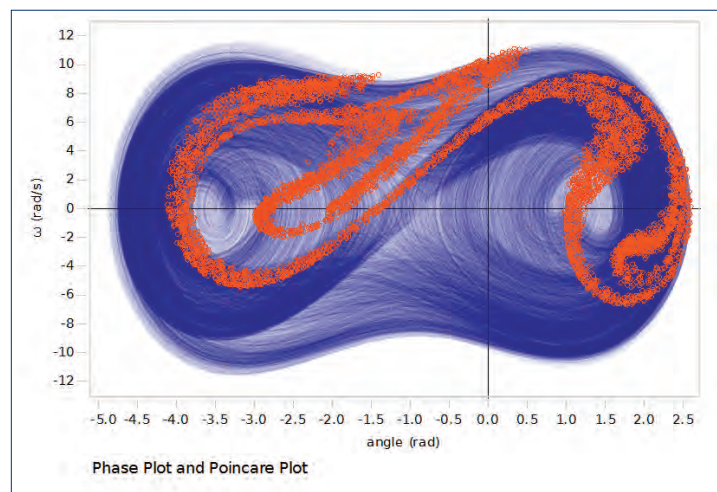
The chaotic behavior of a driven nonlinear pendulum is explored by graphing its motion in phase space and by making a Poincare plot. These plots are compared to the motion of the pendulum when it is not chaotic.

The oscillator consists of an aluminum disk connected to two springs. A point mass on the edge of the aluminum disk makes the oscillator nonlinear. The frequency of the sinusoidal driver can be varied to investigate the progression from predictable motion to chaotic motion. Magnetic damping can be adjusted to change the character of the chaotic motion. The angular position and velocity of the disk are recorded as a function of time using a Rotary Motion Sensor. A real-time phase plot is made by graphing the Angular Velocity vs. the Displacement Angle of the Oscillation.

The Poincare plot is also graphed in real time and superimposed on the phase plot. This is achieved by recording the point on the phase plot once every cycle of the driver arm as the driver arm blocks a photogate.

PASCO Advantage:

PASCO Capstone can graph the motion in phase space and superimpose the Poincare plot in real time, showing students how the motion in phase space relates to the actual motion of the oscillator.



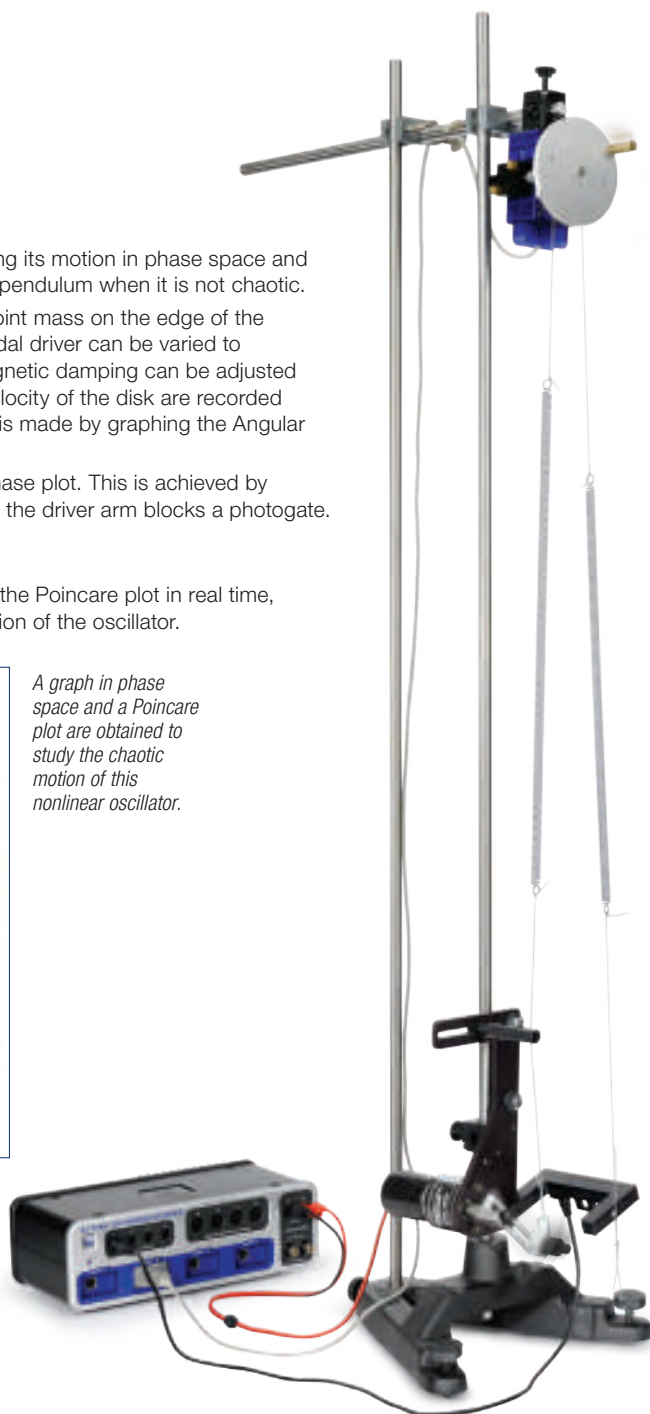
A graph in phase space and a Poincare plot are obtained to study the chaotic motion of this nonlinear oscillator.

The Poincare plot (in orange) shows the pendulum's Velocity vs. Position once per revolution of the driver. The purple background is the phase plot.

This phase plot (Angular Velocity vs. Angle) is graphed in PASCO Capstone using partial opacity, so the trace gets darker as it traces back over itself.

Includes:

- | | |
|-----------------------------------|----------|
| • Large Rod Base | ME-8735 |
| • 120 cm Stainless Steel Rod | ME-8741 |
| • 45 cm Stainless Steel Rod | ME-8736 |
| • Multi-Clamps (2) | ME-9507 |
| • Chaos/Driven Harmonic Accessory | CI-6689A |
| • Mechanical Oscillator/Driver | ME-8750 |
| • PASPORT Rotary Motion Sensor | PS-2120A |
| • Photogate Head | ME-9498A |



Download This Experiment

The FREE experiment files include a pdf of the student instructions and a PASCO Capstone™ workbook file. Download this experiment at pasco.com/CapstoneExperiments.

Order Information

Chaos Experiment.....	EX-5523A
Required:	
550 or 850 Universal Interface.....	pp. 20-23
PASCO Capstone Software.....	pp. 8-11

Driven Damped Harmonic Oscillations Experiment

EX-5522A

Concepts:

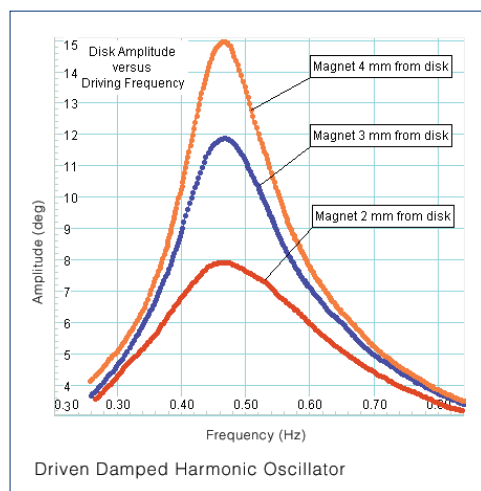
- ▶ **Resonance curves for an oscillator:** Amplitude vs. Frequency
- ▶ Resonant frequency
- ▶ Period of a pendulum
- ▶ Effect of magnetic damping on shape of resonance curve
- ▶ Phase difference between oscillator and driver at low, resonant, and high frequencies

In this experiment, the resonance of a driven damped harmonic oscillator is examined by plotting the Oscillation Amplitude vs. Frequency for various amounts of damping.

The oscillator consists of an aluminum disk with a pulley connected to two springs by a string. The angular positions and velocities of the disk and the driver are recorded as a function of time using two Rotary Motion Sensors. The amplitude of the oscillation is plotted vs. the driving frequency for different amounts of magnetic damping. Increased damping is provided by moving an adjustable magnet closer to the aluminum disk.

PASCO Advantage:

The combination of PASCO Capstone software and the 850 Universal Interface has the power to sweep through the driver frequencies and the capability to plot the Amplitude vs. the Driver Frequency in real time.



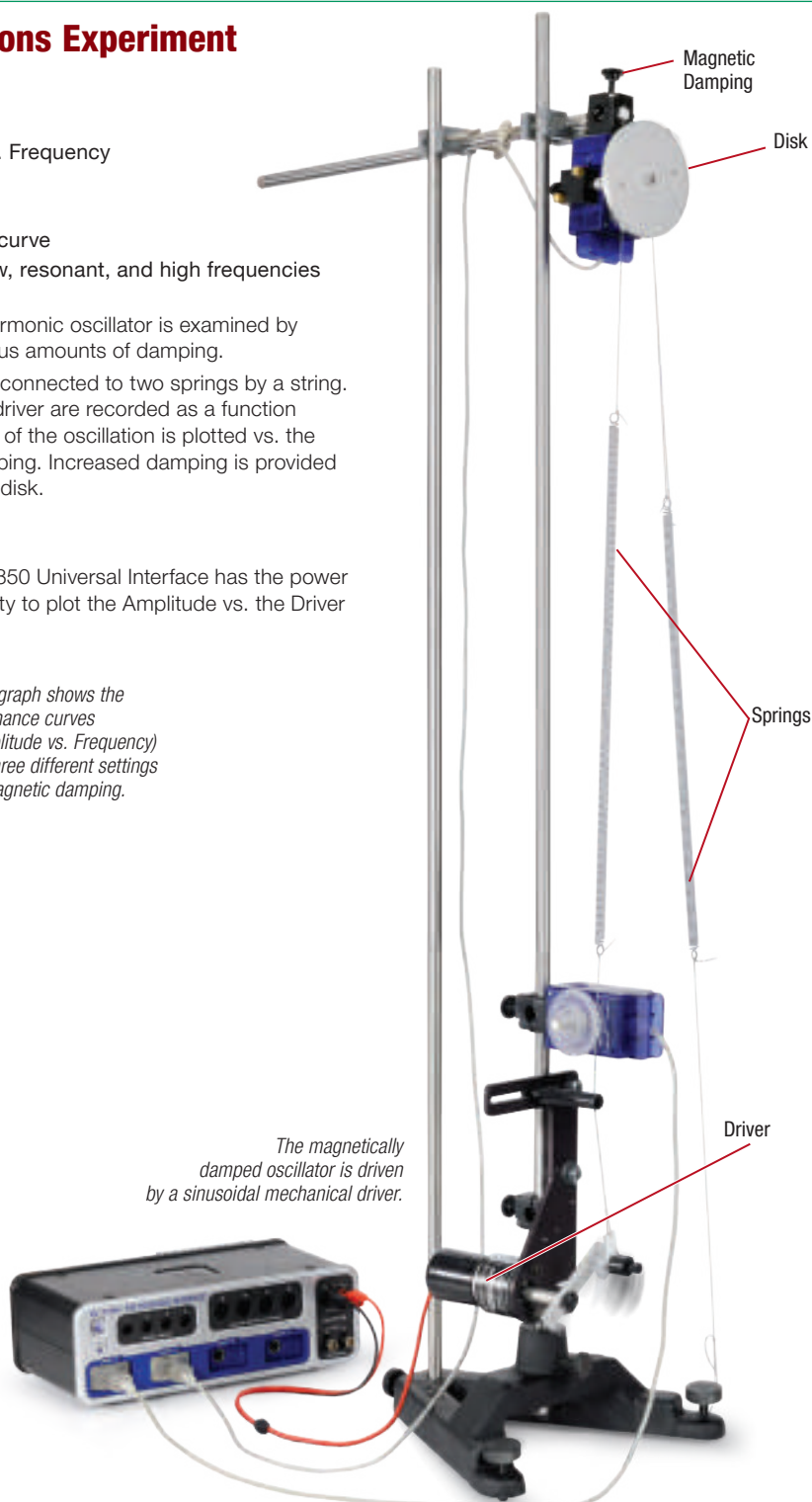
This graph shows the resonance curves (Amplitude vs. Frequency) for three different settings of magnetic damping.

Includes:

- PASPORT Rotary Motion Sensor (2) PS-2120A
- Mechanical Oscillator/Driver ME-8750
- Chaos/Driven Harmonic Accessory CI-6689A
- Large Rod Base ME-8735
- 120 cm Stainless Steel Rod ME-8741
- 45 cm Stainless Steel Rod ME-8736
- Multi-Clamps (2) ME-9507
- Braided Physics String SE-8050

Download This Experiment

The FREE experiment files include a pdf of the student instructions and a PASCO Capstone™ workbook file. Download this experiment at pasco.com/CapstoneExperiments.



Order Information

Driven Damped Harmonic Oscillations Experiment.....	EX-5522A	
Required:		
850 Universal Interface.....	UI-5000	pp. 20-23
PASCO Capstone Software.....		pp. 8-11
Hooked Mass Set.....	SE-8759	p. 215
Digital Calipers.....	SE-8710	p. 208

Structures

Basic Bridges

EX-5556

Concepts:

- Learn about different types of bridges through hands-on exploration.
- Measure the tension/compression in beams for different bridge designs.

Measuring Loads

Each bridge is loaded by hanging a weight from the bridge. The tension and compression in the I-Beams are measured with Load Cells. The Load Cells can be moved around to explore the load in every beam in the bridge.

Rectangular Segments

First, students build a bridge with rectangular segments. Of course, bridges are never made this way, but students will never understand why until they try it.

Triangular Segments

Next, students build a Warren bridge with triangular segments. This shows how much stronger triangular segments are than rectangular segments.

Effect of Scale

Students build a second Warren bridge on a different scale to discover how the forces change in this bridge, which has twice the number of segments but spans the same distance.

Effect of Adding Verticals

Verticals are added to the larger Warren bridge. Students will find that the loads do not change when the verticals are added; So why are verticals used?

Full Warren Bridge vs Pratt Bridge

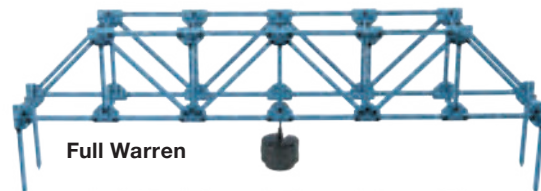
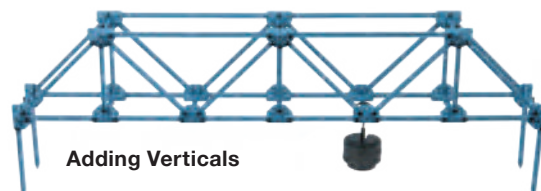
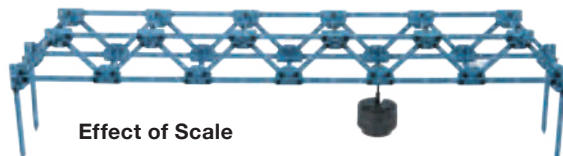
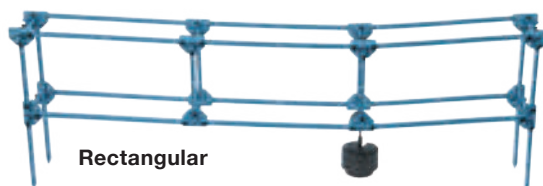
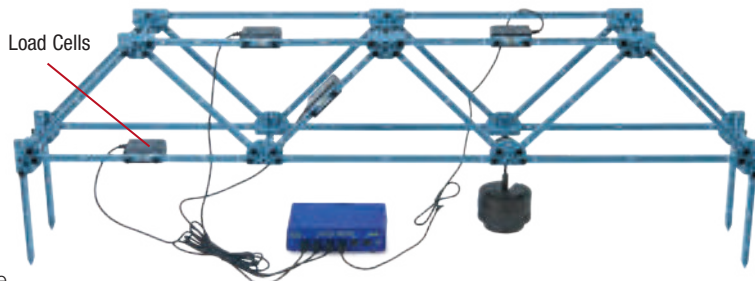
Additional verticals are added to make a Full Warren bridge. Then the students change the Full Warren to a Pratt bridge. How are the forces different in a Pratt compared to a Full Warren?

Includes:

- | | |
|-------------------------------------|---------|
| • Truss Set Members (3) | ME-6993 |
| • Truss Set Screws (3) | ME-6994 |
| • Structures #6 I-Beam Spares | ME-7008 |
| • Large Slotted Mass Set (2 kg set) | ME-7589 |
| • PASPORT Load Cell Amplifier | PS-2198 |
| • 100 N Load Cells (4) | PS-2200 |

Download This Experiment

The FREE experiment files include a pdf of the student instructions and a PASCO Capstone™ workbook file. Download this experiment at pasco.com/CapstoneExperiments.



Order Information

Basic Bridges..... EX-5556

Required:

550 or 850 Universal Interface pp. 20-23

OR

AirLink..... p. 50

PASCO Capstone Software pp. 8-11

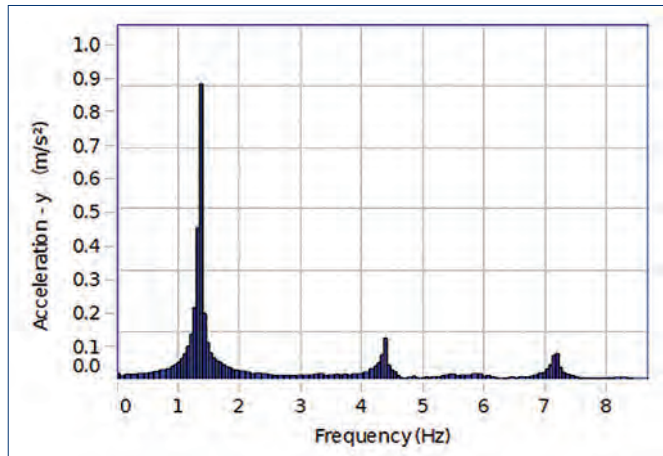
Shaking Tower Experiment

EX-5555

Concepts:

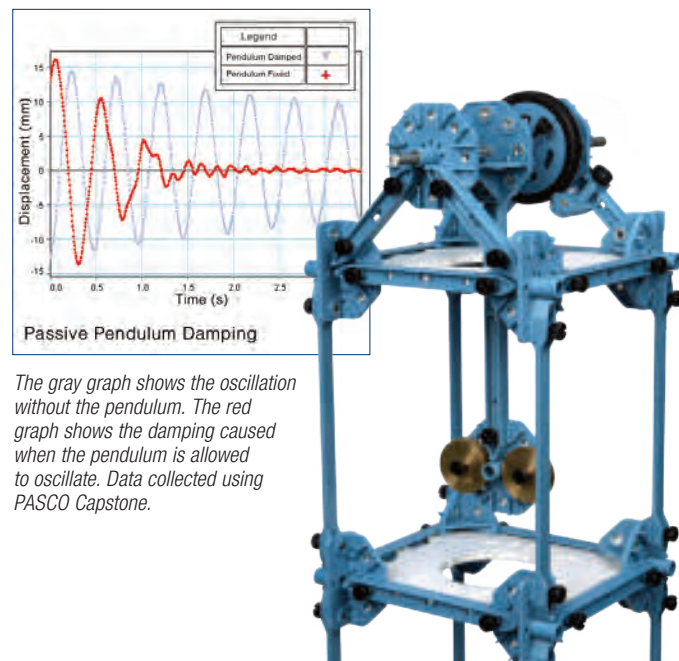
- Explore the resonance modes
- Measure accelerations with wireless sensors
- Demonstrate passive damping

Built from PASCO Structures beams, this tower is made to oscillate in its various resonance modes by a driver attached by a rubber band to the first floor of the tower. Wireless Load Cells with Accelerometers are attached to each floor to record how much shaking each floor experiences.

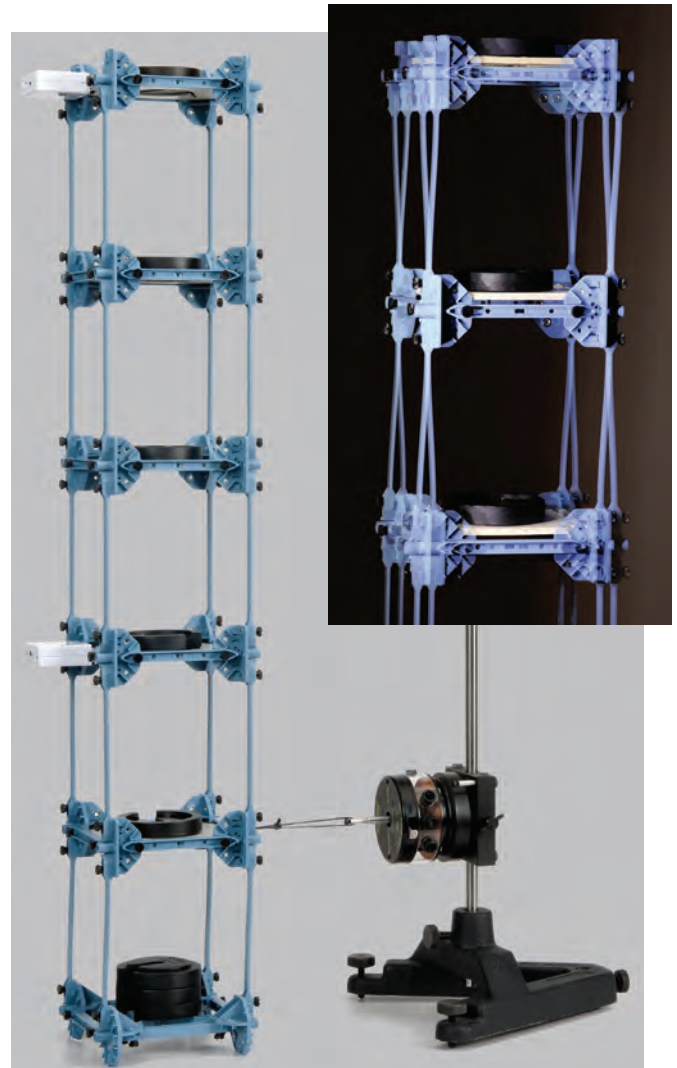


This FFT, generated in PASCO Capstone software, shows the frequency responses of the top Wireless Load Cell/Accelerometer.

In the second part of the experiment, a damping pendulum is installed on top of the tower. In modern buildings, passive damping mechanisms are installed to damp out oscillations during earthquakes. The damping pendulum in this tower quickly stops oscillations.



The gray graph shows the oscillation without the pendulum. The red graph shows the damping caused when the pendulum is allowed to oscillate. Data collected using PASCO Capstone.



The tower is shaken by the Mechanical Wave Driver, which is powered by an 850 Universal Interface or Function Generator.

Includes:

- | | |
|--|----------|
| • Shaking Tower | ME-7018 |
| • Wave Driver | WA-9855 |
| • 2-Meter Patch Cord Set | SE-9415A |
| • Large Rod Base | ME-8735 |
| • Round Base with Rod | ME-8270 |
| • Large Slotted Mass Set | ME-7566 |
| • Wireless Load Cell and Accelerometer (4) | PS-3216 |

Download This Experiment

The FREE experiment files include a pdf of the student instructions and a PASCO Capstone™ workbook file. Download this experiment at pasco.com/CapstoneExperiments.

Order Information

Shaking Tower Experiment.....	EX-5555
Required:	
850 Universal Interface	pp. 20-22
OR	
Function Generator	PI-8127 p. 274
PASCO Capstone Software.....	pp. 8-11

Structures

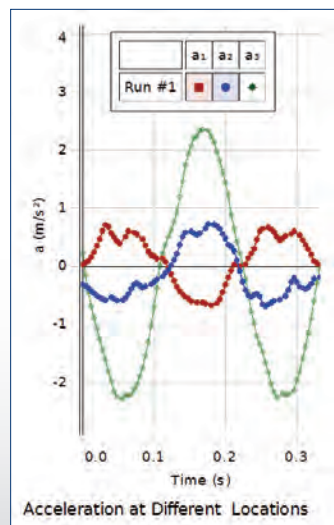
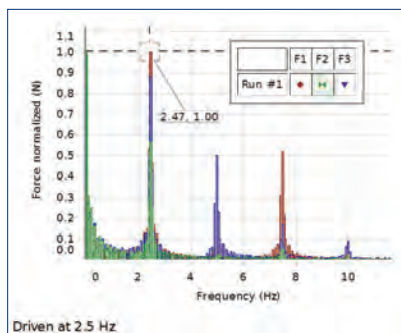
Bridge Vibrations Experiment

EX-5548

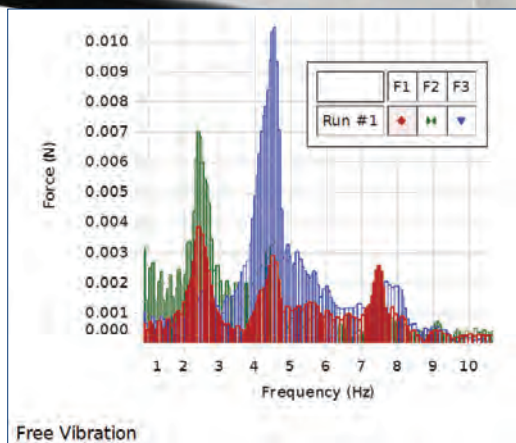
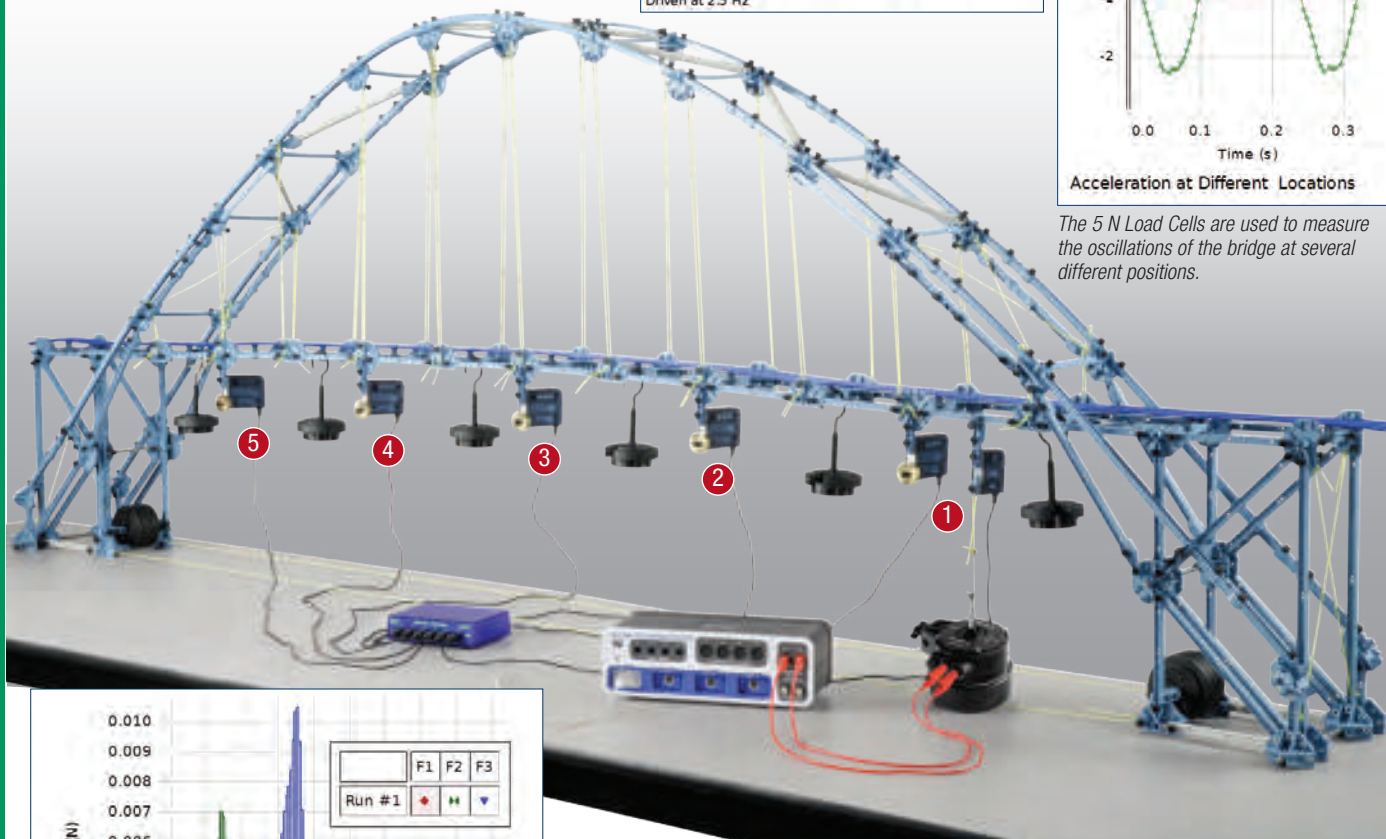
Concepts:

- Resonance in complex systems
- Driven vs. free vibrations

The resonance of the bridge is characterized by driving the bridge at different resonant frequencies. Note how different the amplitudes are at different locations on the bridge.



The 5 N Load Cells are used to measure the oscillations of the bridge at several different positions.



The bridge is struck by hand and allowed to freely oscillate. Using PASCO Capstone™, the FFT shows that there are several resonant frequencies. Note how different the amplitudes are at different locations on the bridge.

Includes:

- Large Structures Set ME-7003
- PASPORT Load Cell Amplifier PS-2198
- 100 N Load Cell PS-2200
- 5 N Load Cell (5) PS-2201
- Wave Driver WA-9855
- Banana Plug Cord-Red (5 pack) SE-9750
- Rubber Cord for IDS System (30m spool) ME-8986
- Large Slotted Mass Set (2 kg set) (4) ME-7589
- Short Mass Hanger (2) ME-7590
- 20 g Replacement Mass Set (3 sets of 6) ME-8983

Order Information

Bridge Vibrations Experiment EX-5548

Required:

850 Universal Interface pp. 20-22

PASCO Capstone Software pp. 8-11

Download This Experiment

The FREE experiment files include a pdf of the student instructions and a PASCO Capstone™ workbook file. Download this experiment at pasco.com/CapstoneExperiments.

Specific Heat Experiment

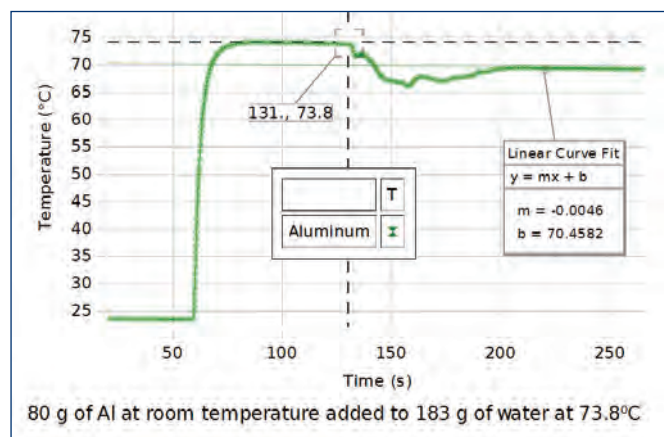
EX-5624A

Topics Covered:

- Thermal energy
- Equilibrium temperature
- Specific heat

Designed for use with PASCO Capstone software, this experiment demonstrates that materials can be identified using specific heat as a measurable characteristic. A known mass of water is used and the unknown material is placed in the water. The initial temperature of the water and the unknown material are measured. The equilibrium temperature is found and from this the specific heat of the unknown material is derived.

By performing this experiment in two ways (water warming, water cooling) students explore how experiment design may alter results. Finally students explore sources of error and magnitude of error.



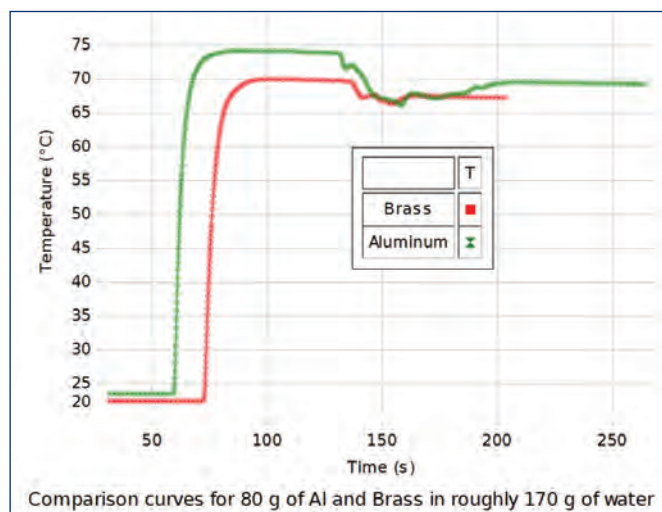
Room temperature Aluminum is added to hot water. After 210 s, the system comes to equilibrium and slowly cools. A linear fit to the cooling curve allows extrapolation back to find the equilibrium temperature that would have occurred at 131 s when the Aluminum was added, if the system had come to equilibrium instantaneously. This allows measurement of the specific heat within approximately 10%.

Includes:

- Wireless Temperature Sensor PS-3201
- Calorimetry Cup with Lid
- Steam Generator TD-8888
- Ohaus Triple-Beam Balance (without Tare) SE-8723
- Braided Physics String SE-8050
- Specific Heat Set SE-6849

Download This Experiment

The FREE experiment files include a pdf of the student instructions and a PASCO Capstone™ workbook file. Download this experiment at pasco.com/CapstoneExperiments.



Comparison of a similar system shows that Aluminum causes about twice the drop in water temperature as does brass. The cooling slopes before and after support Newton's Law of Cooling.

Order Information

Specific Heat Experiment..... EX-5624A
 Required:
 PASCO Capstone Software..... pp. 8-11

View the 550 or 850 Universal Interface-compatible version of this experiment (EX-5524B) online at pasco.com/capstoneexperiments

Thermodynamics

Electrical Equivalent of Heat Experiment

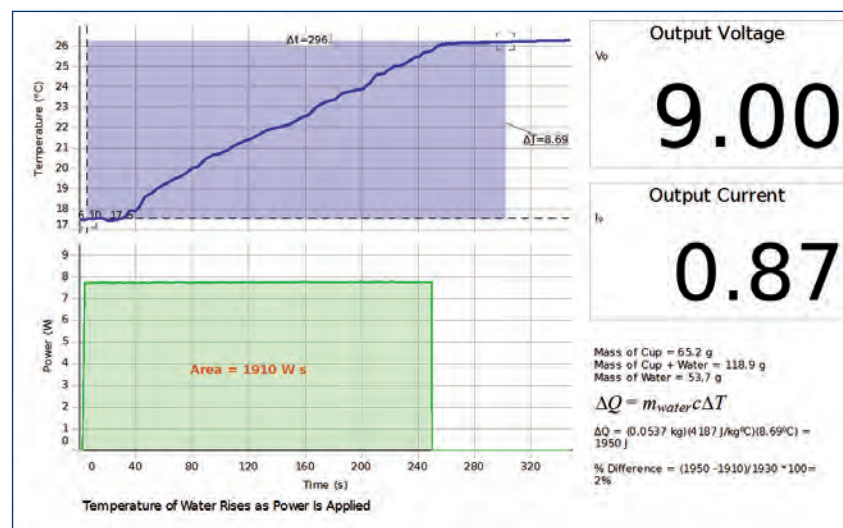
EX-5625

Concepts:

- Compare electrical energy input to changes in internal energy

A Wireless Current Sensor and a Wireless Voltage Sensor are used to measure the electrical power delivered to the resistor that is heating the water and a Wireless Temperature Sensor is used to measure the increase in temperature of the water.

The amount of electrical energy used to heat the water is equal to the area under the power versus time curve. The amount of heat delivered to the water can be calculated using the increase in temperature and the mass of the water. The comparison of the electrical energy to the heat results in a value for the number of Joules in a calorie.



The bottom graph displays the power output from the generator and the top graph shows the increase in temperature. The amount of electrical energy used to heat the water is determined by finding the area under the Power vs. Time curve.

Includes:

- Energy Transfer – Calorimeter ET-8499
- Wireless Temperature Sensor PS-3201
- Wireless Voltage Sensor PS-3211
- Wireless Current Sensor PS-3212
- Ohaus Triple-Beam Balance (with Tare) SE-8707
- Student Power Supply SE-8828

Download This Experiment

The FREE experiment files include a pdf of the student instructions and a PASCO Capstone™ workbook file. Download this experiment at pasco.com/CapstoneExperiments.



Order Information

Electrical Equivalent of Heat Experiment EX-5625

Required:

PASCO Capstone Software pp. 8-11

View the 550 or 850 Universal Interface-compatible version of this experiment (EX-5525) online at pasco.com/capstoneexperiments

Ideal Gas Law Experiment

EX-5627

Concepts:

- Ideal Gas Law
- Boyle's Law
- Gay-Lussac's Law

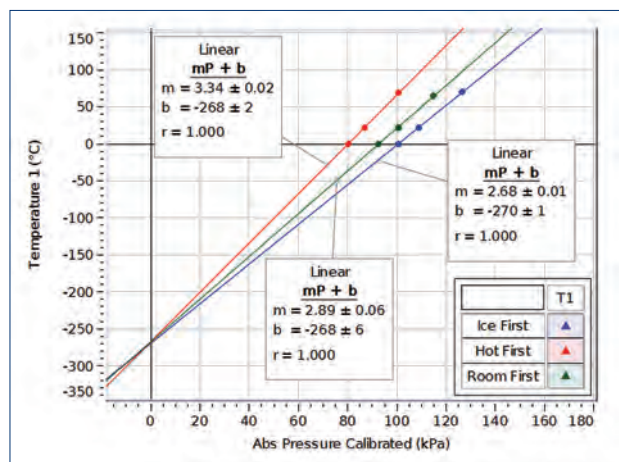
In this experiment designed for use with PASCO Capstone software, the temperature, volume, and pressure of a gas are measured simultaneously to show that they change according to the Ideal Gas Law. Two special cases of the Ideal Gas Law are also examined: constant volume (Gay-Lussac's Law) and constant temperature (Boyle's Law). A syringe is used to vary the volume at constant temperature. A sphere of constant volume is immersed in different temperature water baths to show the change in pressure.



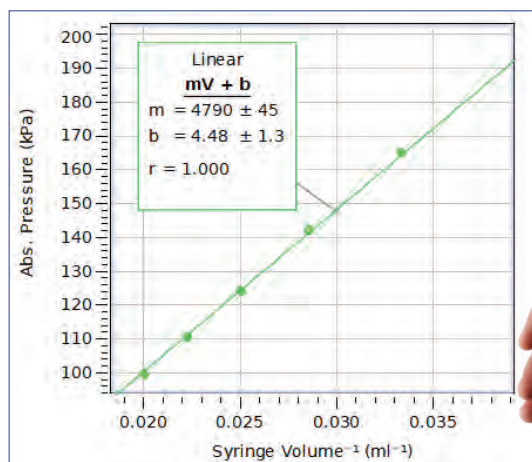
For the Ideal Gas Syringe (shown above) the slope of the Pressure vs. Inverse Volume is nRT .

PASCO Advantage:

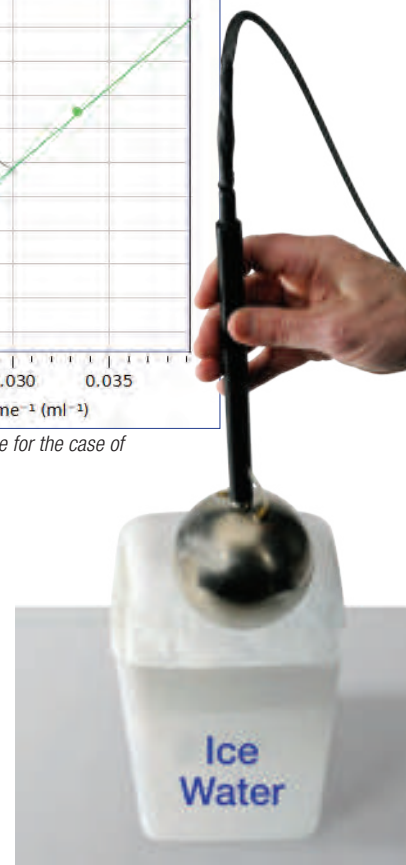
The Ideal Gas Syringe and Absolute Zero Sphere have a thermistor with small mass that responds quickly to temperature changes.



For the Absolute Zero Apparatus (shown at right), which has constant volume, the Pressure vs. Temperature graphs have different slopes corresponding to the different number of moles in the container.



Pressure is plotted versus Inverse Volume for the case of constant temperature.



Includes:

- Ideal Gas Law Apparatus TD-8596A
- Wireless Pressure Sensor PS-3203
- Wireless Temp Link PS-3222
- Absolute Zero Sphere TD-8595
- 3-Liter Plastic Tub (2-Pack) ME-7559

Download This Experiment

The FREE experiment files include a pdf of the student instructions and a PASCO Capstone™ workbook file. Download this experiment at pasco.com/CapstoneExperiments.

Order Information

Ideal Gas Law Experiment..... EX-5627
 Required:
 PASCO Capstone Software..... pp. 8-11
 Digital Calipers SE-8710 p. 208

View the 550 or 850 Universal Interface-compatible version of this experiment (EX-5527) online at pasco.com/capstoneexperiments

Thermodynamics

Blackbody Radiation Experiment

EX-5529A

Concepts:

- Blackbody spectrum
- Peak wavelength vs. temperature

In this experiment designed for use with PASCO Capstone software, the classic blackbody spectrum of light intensity versus wavelength is obtained for a light bulb and the shift in the peak wavelength is demonstrated for different bulb temperatures.

The spectrum of an incandescent light bulb is scanned by hand using a prism spectrophotometer, which measures relative light intensity as a function of angle. A Broad Spectrum Light Sensor is used with a prism so that the entire spectrum (approximately 400 nm to 2500 nm) can be scanned without the overlapping orders caused by a grating. The wavelengths corresponding to the angles are calculated using the equations for a prism spectrophotometer. The relative light intensity can then be plotted as a function of wavelength as the spectrum is scanned, resulting in the characteristic blackbody curve. The intensity of the light bulb is reduced, reducing the temperature, and the scan is repeated to show how the curves nest with a shift in the peak wavelength.

The temperature of the bulb's filament can then be measured indirectly by determining the resistance of the bulb from the measured voltage and current. From the temperature, the theoretical peak wavelength can be calculated and compared to the measured peak wavelength.

Note: The results are qualitative, and suitable for introductory classes only.

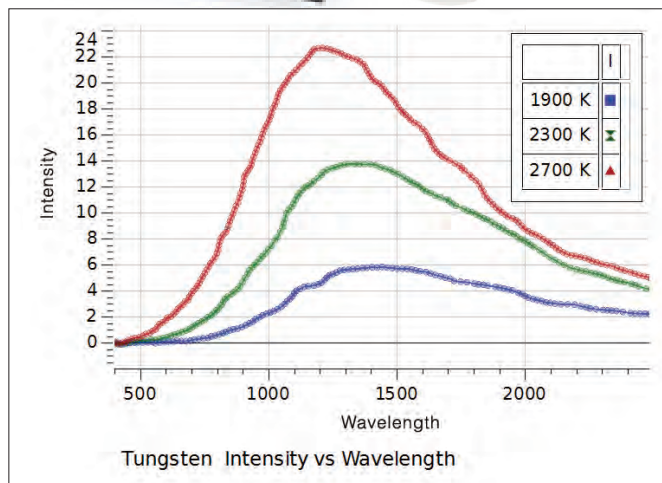
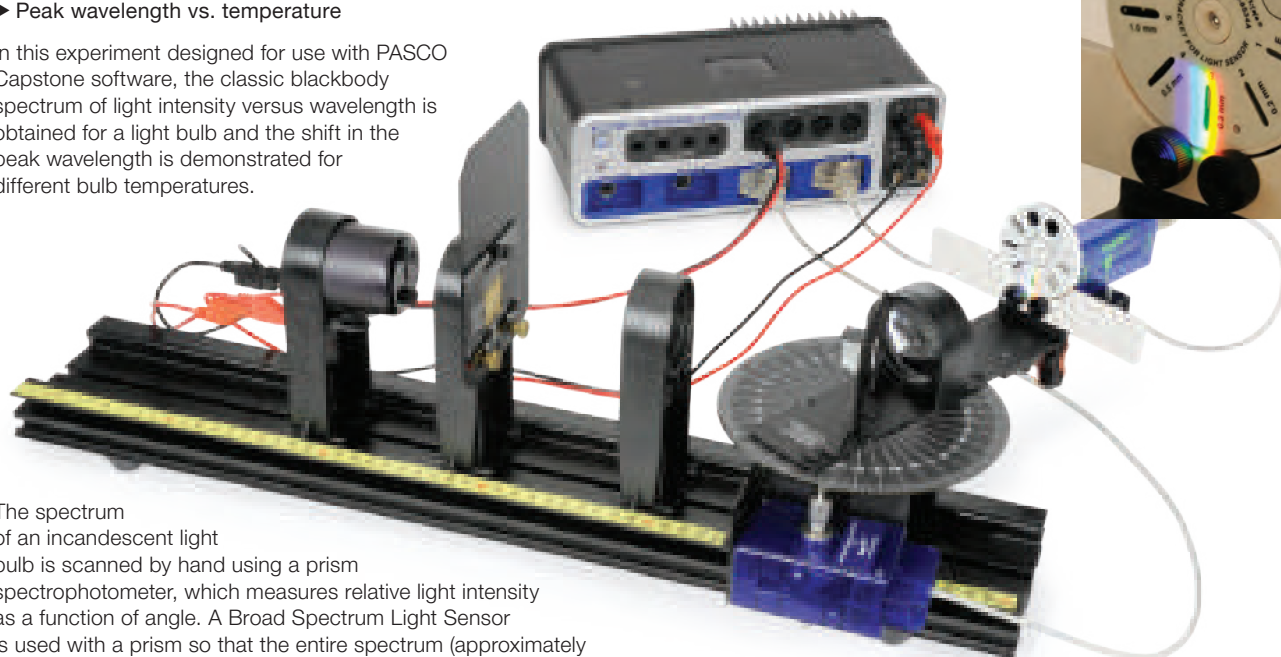
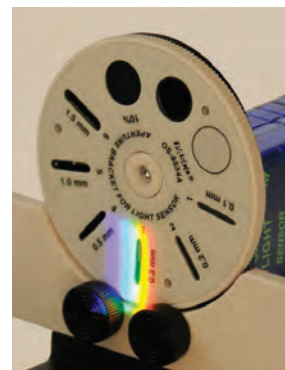
PASCO Advantage:

The light bulb is powered by the interface, making it easy to change its temperature by changing the voltage across the bulb. All the complex calculations for the angle-to-wavelength conversion are stored in the setup file for PASCO Capstone.

Includes:

- | | |
|---|----------|
| • Prism Spectrophotometer Kit | OS-8544 |
| • Optics Benches (60 cm) | OS-8541 |
| • Educational Spectrophotometer Accessory Kit | OS-8537 |
| • Aperture Bracket | OS-8534A |
| • PASPORT Broad Spectrum Light Sensor | PS-2150 |
| • PASPORT Rotary Motion Sensor | PS-2120A |
| • Voltage Sensor (unshrouded) | UI-5100 |
| • Replacement Light Bulbs (10) | SE-8509 |
| • Banana Plug Cord-Black (5 Pack) | SE-9751 |

The continuous blackbody spectrum is scanned using a prism spectrophotometer.



Classic textbook diagram of the Intensity vs. Wavelength blackbody curves can be produced with real data. In this graph, the peak wavelength in the blackbody curve shifts as the source temperature is decreased.

Download This Experiment

The FREE experiment files include a pdf of the student instructions and a PASCO Capstone™ workbook file. Download this experiment at pasco.com/CapstoneExperiments.

Order Information

Blackbody Radiation Experiment..... EX-5529A

Required:

550 or 850 Universal Interface* pp. 20-23
PASCO Capstone Software pp. 8-11

Heat Engine Cycles Experiment

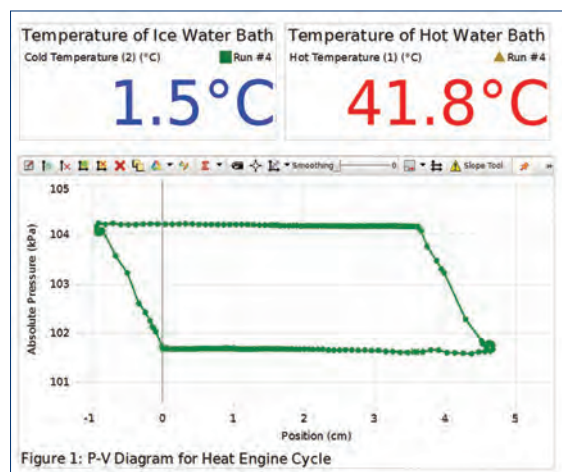
EX-5630

Concepts:

- Heat engine efficiency
- Isothermal processes
- Isobaric processes
- Ideal Gas Law

A P-V diagram is generated as a heat engine is taken through a cycle. From this diagram, the heat added to the gas and the work done by the engine are measured to determine the efficiency of the engine. This actual efficiency is compared to the theoretical maximum efficiency.

The heat engine consists of air inside a cylinder that expands when an attached can is immersed in hot water. The expanding air pushes on a piston and does work by lifting a weight. The heat engine cycle is completed by immersing the can in cold water, which returns the air pressure and volume to the starting values.



The PASCO Capstone™ graph shows an isobaric/isothermal heat engine cycle operating between a cold water bath at 1.5°C and a hot water bath at 41.8°C.

The cycle is performed as follows:

- With the can in the cold bath, the 200 g mass is placed on the platform.
- The can is moved from the cold bath to the hot bath.
- The 200 g mass is removed from the platform.
- The can is moved from the hot bath to the cold bath.

The change in pressure is measured with a Wireless Pressure Sensor. The change in piston height is measured by the attached string over the Wireless Rotary Motion Sensor pulley. The change in volume is calculated by multiplying the change in piston height by the piston cross-sectional area.

PASCO Advantage:

This operating heat engine shows how a difference in temperature can be used to do work. Each part of the cycle is easily identifiable, and the actual efficiency as well as the maximum possible efficiency can be easily determined.

Includes:

- | | |
|-------------------------------------|----------|
| • Heat Engine and Gas Law Apparatus | TD-8572A |
| • Large Rod Base | ME-8735 |
| • Mass and Hanger Set | ME-8979 |
| • 3-Liter Plastic Tub (2-Pack) | ME-7559 |
| • Thread | |
| • Stainless Steel Temp Probe (2) | PS-2153 |
| • 90 cm Stainless Steel Rod | ME-8738 |
| • Wireless Rotary Motion Sensor | PS-3220 |
| • Wireless Temperature Link (2) | PS-3222 |
| • Wireless Pressure Sensor | PS-3203 |

Order Information

Heat Engine Cycle Experiment EX-5630
 Required:
 PASCO Capstone Software pp. 8-11

Download This Experiment

The FREE experiment files include a pdf of the student instructions and a PASCO Capstone™ workbook file. Download this experiment at pasco.com/CapstoneExperiments.

View the 550 or 850 Universal Interface-compatible version of this experiment (EX-5530B) online at pasco.com/capstoneexperiments

Thermodynamics

Ratio of Specific Heat Experiment

EX-5631

Concepts:

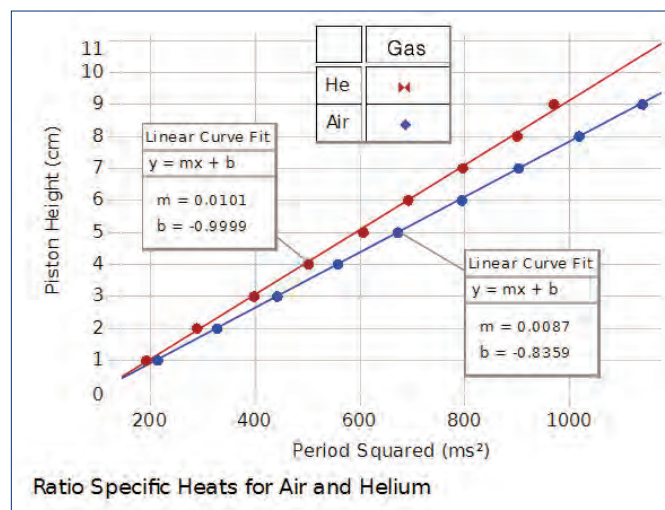
- ▶ C_p/C_v for a gas
- ▶ Rüchardt's method of measuring the ratio of specific heats
- ▶ Adiabatic process

In this experiment, the ratio of specific heat capacities for air is determined using Rüchardt's method of measuring the period of oscillation of the piston in a cylinder filled with air.

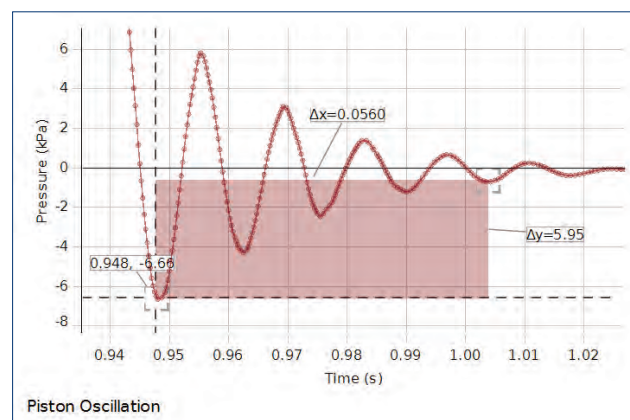
A cylinder is filled with air and a Wireless Pressure Sensor is attached. The piston is plucked by hand and allowed to oscillate. The oscillating pressure is recorded as a function of time and the period is determined. The ratio of specific heat capacities is calculated using the period of oscillation, according to Rüchardt's method.

PASCO Advantage:

Since the oscillations are plotted, it is easy to accurately measure the period of oscillation.



A plot of the Piston Height vs. the Period Squared shows that the period increases as the gas volume increases. The slope of the line is related to the ratio of specific heats (C_p/C_v) and is different for the two gases.



The pressure oscillates after the piston is plucked by hand.

**Includes:**

- Heat Engine and Gas Law Apparatus TD-8572A
- Large Rod Base ME-8735
- 45 cm Stainless Steel Rod ME-8736
- Wireless Pressure Sensor PS-3202

Download This Experiment

The FREE experiment files include a pdf of the student instructions and a PASCO Capstone™ workbook file. Download this experiment at pasco.com/CapstoneExperiments.

Order Information

Ratio of Specific Heat Experiment EX-5631
 Required:
 PASCO Capstone Software pp. 8-11

View the 550 or 850 Universal Interface-compatible version of this experiment (EX-5531A) online at pasco.com/capstoneexperiments

Electrostatic Charge Experiment

EX-5532

Topics Covered:

- Methods of Charging
- Charge Distribution
- Conservation of Charge

Using classic equipment (a Faraday Ice Pail and Conductive Spheres), students learn to charge objects by direct contact and by induction. The charge is measured using a high impedance electrometer.

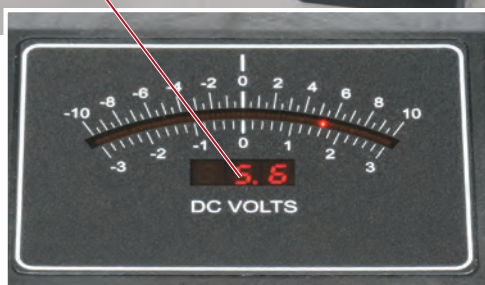
Students explore the distribution of charge on different shaped conductive shapes. A sphere with a hole in it is provided to show that no charge resides on the inner surface of the conductor when it is charged.



Use the ball end to sample inside the hollow sphere.



New Digital Readout



Includes:

- | | |
|------------------------------------|----------|
| • Basic Electrometer | ES-9078A |
| • Charge Producers and Proof Plane | ES-9057C |
| • Faraday Ice Pail | ES-9042A |
| • Conductive Spheres | ES-9059C |
| • Conductive Shapes | ES-9061 |
| • Electrostatics Voltage Source | ES-9077 |

Order Information

Electrostatic Charge Experiment EX-5532

Required:

PASCO Capstone Software pp. 8-11
(No interface required.)

Download This Experiment

The FREE experiment files include a pdf of the student instructions and a PASCO Capstone™ workbook file. Download this experiment at pasco.com/CapstoneExperiments.

Electromagnetism

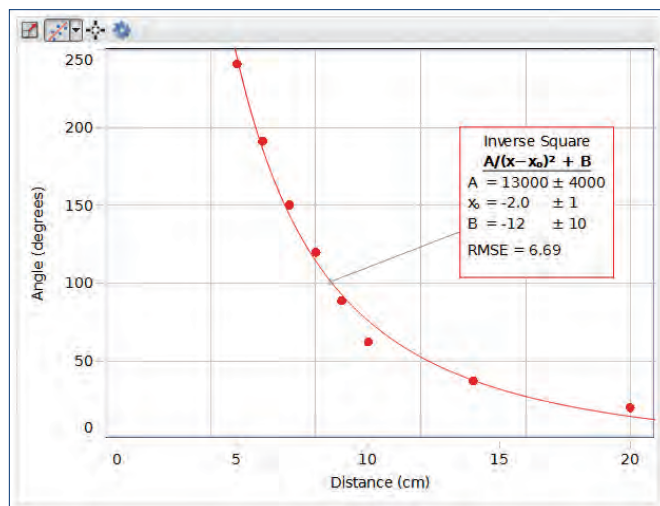
Coulomb's Law Experiment

EX-9930B

Concepts:

- Verify the Inverse Square Law: $F \sim 1/R^2$
- Verify the Force/Charge Relationship: $F \sim q_1 q_2$
- Determine Coulomb's Constant: $k = 9.0 \times 10^9 \text{ Nm}^2/\text{C}^2$

A conductive sphere is mounted on the end of an insulating counterbalanced rod and suspended from a very thin torsion wire. An identical sphere is mounted on a calibrated linear track and can be positioned at various distances from the first sphere. When the conductive spheres are charged, the force between them is proportional to the twist of the torsion wire that is required to bring the balance back to its equilibrium position. Introductory physics students can determine the Inverse Square Law in a simple experiment, while advanced students can perform investigations into all the variables involved in electrostatic repulsion.



Electrostatic force is directly proportional to the angle of twist, and the angle of twist is proportional to the inverse square of the separation of the balls.



When an electrostatic force is applied, the torsion wire is twisted to return the balance to equilibrium. The twist of the wire is proportional to the electrostatic repulsion force.

Includes:

- | | |
|------------------------------------|----------|
| • Coulomb's Law Apparatus | ES-9070 |
| • Kilovolt Power Supply | SE-9586 |
| • Basic Electrometer | ES-9078A |
| • Faraday Ice Pail | ES-9042A |
| • Charge Producers and Proof Plane | ES-9057C |
| • Coulomb's Law Experiment Manual | |

Download This Experiment

Search for EX-9930B at pasco.com

Order Information

Coulomb's Law Experiment EX-9930B
(No interface required.)

Charge of an Electron Experiment

Concepts:

- ▶ Accurately measure the charge of a single electron
- ▶ Recreate Robert Millikan's historical experiment

Small droplets of oil are introduced into a chamber where an electric field of known strength is present. Using the viewing scope and a stopwatch, the velocity of a falling oil droplet is measured and recorded. Next, the electric field in the chamber is increased, causing the oil droplet to move upward. This allows the measurement of the force on the droplet and, ultimately, the charge of the droplet. By measuring the charge of several different oil droplets, the smallest difference in charge between them can be equated to the charge of an electron.



PASCO Advantage:

PASCO's Charge of an Electron Experiment features a 30x, bright-field, erect-image microscope for clear viewing of the oil droplets. The droplet viewing chamber utilizes a special condenser to minimize droplet drift typically caused by droplet illumination and outside air currents. An ionization source allows the droplet charge to be changed.

Experiment components sold separately.

The complete experiment requires:

- Millikan Oil Drop Apparatus AP-8210B
- Basic Digital Multimeter SE-9786A
- High Voltage Power Supply SF-9585A
- Large Rod Base ME-8735
- 45 cm Stainless Steel Rod (2) ME-8736
- Banana Plug Cord-Red (5 pack) SE-9750
- Banana Plug Cord-Black (5 pack) SE-9751
- Charge of an Electron Experiment Manual

Easy Cleaning

The condenser system easily disassembles for cleaning and inspection.

Condenser Housing

Minimum Electric Field Distortion

A 0.5 mm diameter droplet entry hole in the top capacitor plate has a negligible effect on the electric field.

Ionization Source

The thorium-232 alpha source can be activated by the switch on the side of the chamber. The source allows the charge on the oil droplets to be changed.

Droplet Hole Cover

Prevents additional droplets from entering the chamber once the experiment has started.

Polished Surfaces

Polished surfaces on the plate spacer minimize absorption of light (and heat) through the chamber walls.

Electrical Connection

Electrical connection to the top plate.

Condenser Assembly

Order Information

Millikan Oil Drop Apparatus.....	AP-8210B	p. 260, 324
Basic Digital Multimeter.....	SE-9786A	p. 250, 269
High Voltage DC Power Supply.....	SE-9700	p. 273
Large Rod Base.....	ME-8735	p. 204
45 cm Stainless Steel Rod.....	ME-8736	p. 204
Banana Plug Cord-Red (5 pack).....	SE-9750	p. 248
Banana Plug Cord-Black (5 pack).....	SE-9751	p. 248
(No interface required.)		

Electromagnetism

Capacitance Experiment

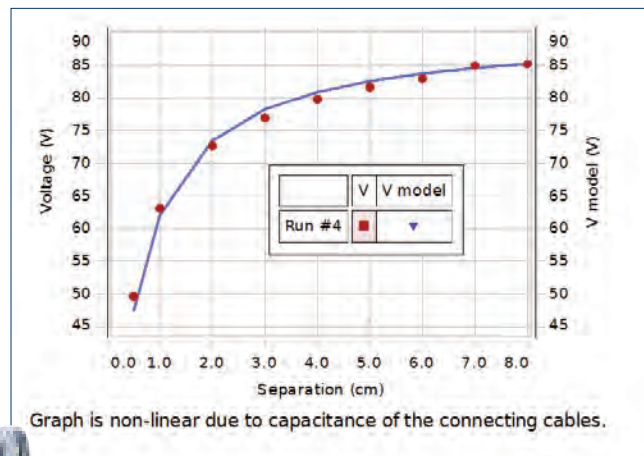
EX-5533

Topics Covered:

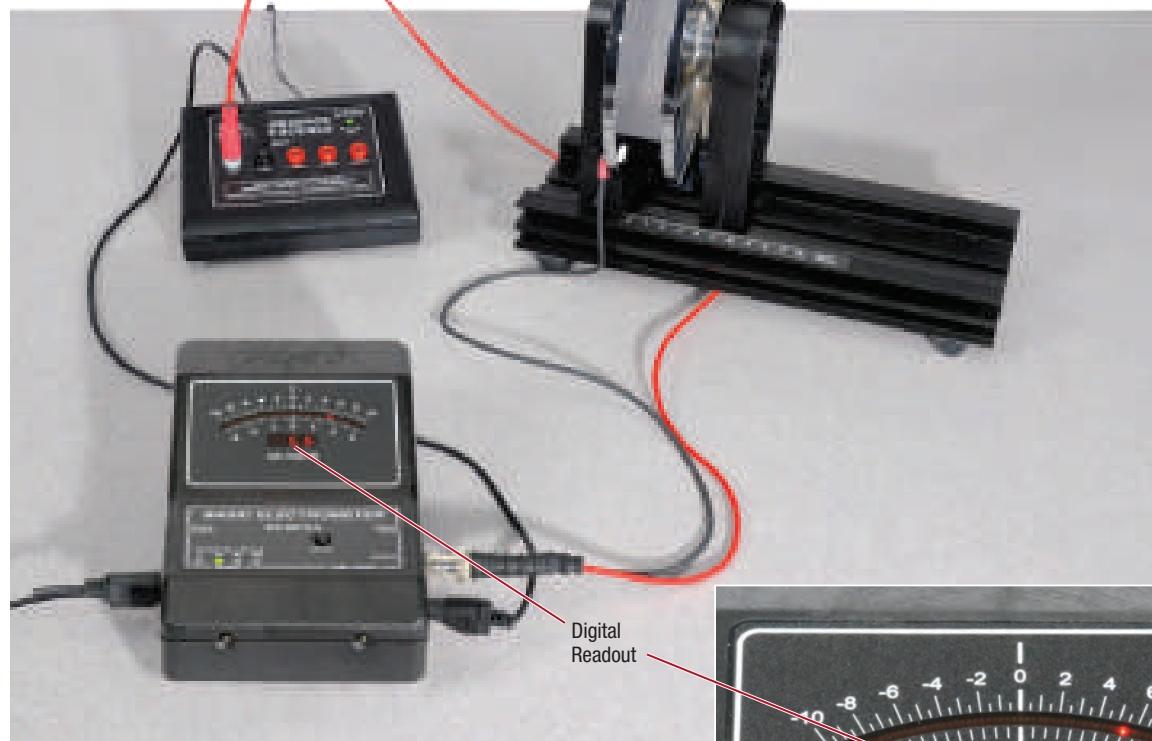
- Capacitance
- Parallel Plate Capacitor
- Factors Affecting Capacitance

This lab explores the effect of varying plate distances and insulating dielectric materials in a variable flat plate capacitor.

The electrometer used in this experiment allows you to measure the voltage across the capacitor plates, without discharging the capacitor, since it has an internal resistance of 1014 ohms.



Manipulation of the computer model allows measurement of the capacitance of the connecting cables and the charge on the system.



Digital
Readout



Includes:

- Basic Electrometer ES-9078A
- Basic Variable Capacitor ES-9079
- Electrostatics Voltage Source ES-9077

Download This Experiment

The FREE experiment files include a pdf of the student instructions and a PASCO Capstone™ workbook file. Download this experiment at pasco.com/CapstoneExperiments.

Order Information

Capacitance Experiment EX-5533
 Required:
 550 or 850 Universal Interface pp. 20-23
 PASCO Capstone Software pp. 8-11

Resistivity Experiment

EX-5534

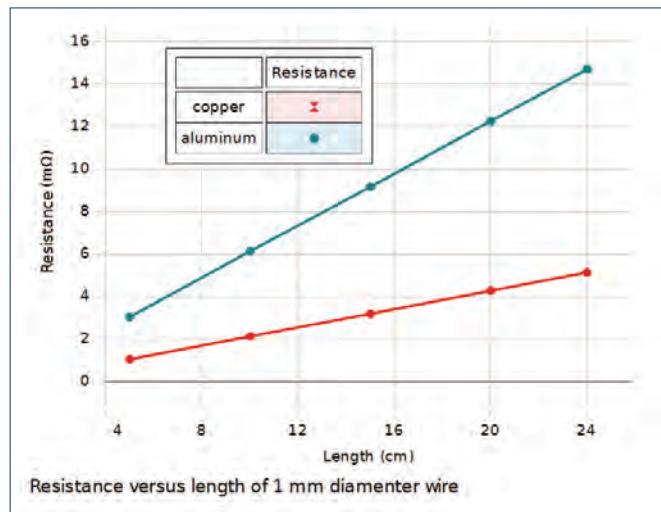
Concepts:

- Relate resistance to wire length
- Determine resistivity of different materials

Discover the relationship between the resistance of a wire and its length, diameter, and the resistivity of the metal.

The current is measured directly by the 850 Universal Interface, and the voltage drop over the selected section of wire is measured by the Voltage Sensor. This allows easy calculation of the resistance of the length of wire. The resistance is plotted vs. the length of the wire, and the slope of the resulting straight line is used to determine the resistivity.

Using wires of the same diameter made of different materials allows examination of the effect of resistivity. Using brass wires with various diameters allows examination of the effect diameter has on resistance.



Since both wires have the same diameter, the resistivity is directly proportional to the slope. The graph shows that the resistivity of copper is about one-third that of aluminum.

The Resistance Apparatus has a slide wire probe to easily change the measured length of the wire, and it utilizes a four wire hook-up to accurately measure the voltage drop. It comes with four different brass wire diameters and four other wire materials.



PASCO Advantage:

The Resistance Apparatus has a slide-wire probe to easily change the measured length of the wire. It utilizes a four-wire hook-up to accurately measure the voltage drop.

The 850 Universal Interface Power Amplifier makes it possible to scan the voltages, allowing more time to examine wires made of different metals and with different diameters.

Includes:

- Resistivity Apparatus EM-8812
- Voltage Sensor (unshrouded) UI-5100
- Banana Plug Cord-Red (5 pack) SE-9750

Download This Experiment

The FREE experiment files include a pdf of the student instructions and a PASCO Capstone™ workbook file. Download this experiment at pasco.com/CapstoneExperiments.

Order Information

Resistivity Experiment..... EX-5534
 Required:
 550 or 850 Universal Interface..... pp. 20-23
 PASCO Capstone Software..... pp. 8-11
 Micrometer..... p. 208

Electromagnetism

Ohm's Law Experiment

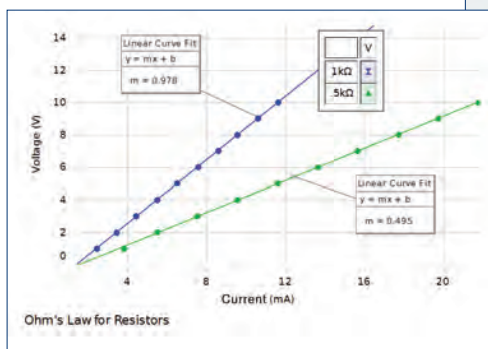
EX-5535

Concepts:

- Relationship between voltage and current

In this experiment, students simultaneously measure both current and voltage for a simple DC circuit. The relationship between current and voltage is explored for different resistors in parallel. A graph of Voltage vs. Current is used to verify Ohm's Law and recognize the physical meaning of slope.

The relationship between voltage and current varies for different resistance values.



Includes:

- Resistor Capacitor Inductor Network UI-5210
- Banana Plug Cord Sets, 30 cm Length (set of 8) SE-7123

Download This Experiment

The FREE experiment files include a pdf of the student instructions and a PASCO Capstone™ workbook file. Download this experiment at pasco.com/CapstoneExperiments.

Order Information

Ohm's Law Experiment..... EX-5535

Required:

550 or 850 Universal Interface..... pp. 20-23

PASCO Capstone Software..... pp. 8-11

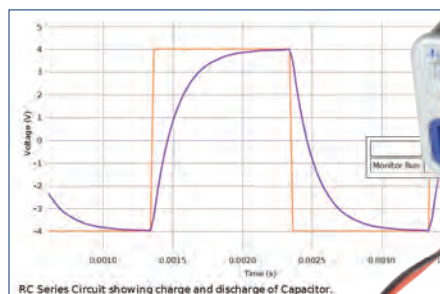
RC Circuit Experiment

EX-5536

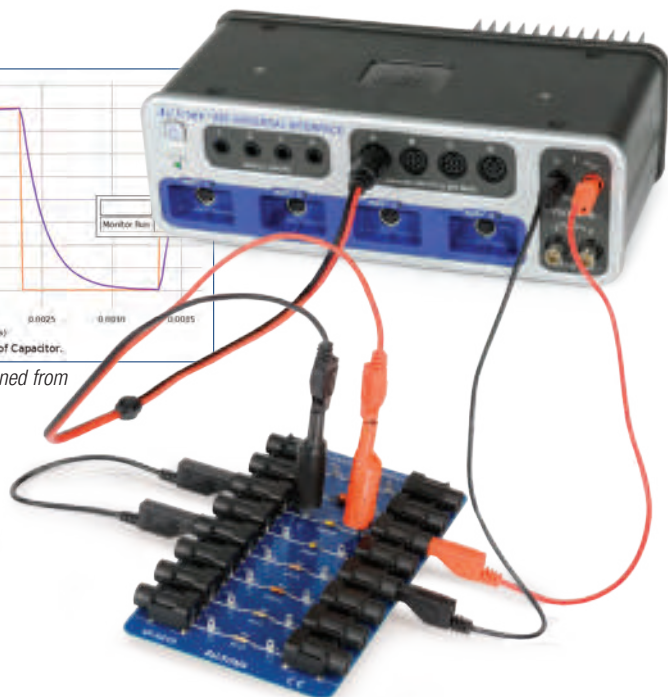
Concepts:

- Charging and discharging a capacitor
- Exponential growth and decay
- Time constants

Students collect data to understand the relationship between charging and discharging rates and the capacitance and resistance in a simple circuit. The time constant is derived and exponential growth and decay are explored.



The actual capacitance is determined from the charge/discharge curve.



PASCO Advantage:

The RC Circuit experiment is extremely simple and transparent to set up. It is very easy to measure the time to half charge. It is also easy to verify that the curve is exponential using the curve-fitting capability of PASCO Capstone software.

Includes:

- Resistor Capacitor Inductor Network UI-5210
- Voltage Sensor (unshrouded) UI-5100
- Banana Plug Cord Sets, 30 cm length (8) SE-7123

Download This Experiment

The FREE experiment files include a pdf of the student instructions and a PASCO Capstone™ workbook file. Download this experiment at pasco.com/CapstoneExperiments.

Order Information

RC Circuit Experiment..... EX-5536

Required:

550 or 850 Universal Interface..... pp. 20-23

PASCO Capstone Software..... pp. 8-11

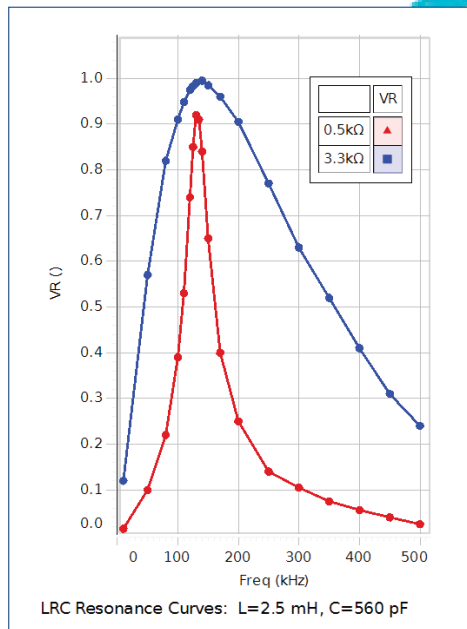
LRC Circuit Experiment

EX-5537

Concepts:

- ▶ LC oscillations
- ▶ Inductive, capacitive, and resistive AC circuits
- ▶ LRC resonant frequency

The response of a series LRC circuit is examined at driving frequencies above, below, and at the resonant frequency. A sinusoidal voltage is applied individually to a resistor, a capacitor, and an inductor. The amplitude of the current and the phase difference between the applied voltage and the current are measured in each of the three circuits to see the effect each component has on the current. Finally, a sinusoidal voltage is applied to an inductor, resistor, and capacitor in series. The amplitude of the current and the phase difference between the applied voltage and the current are measured and compared to theory.



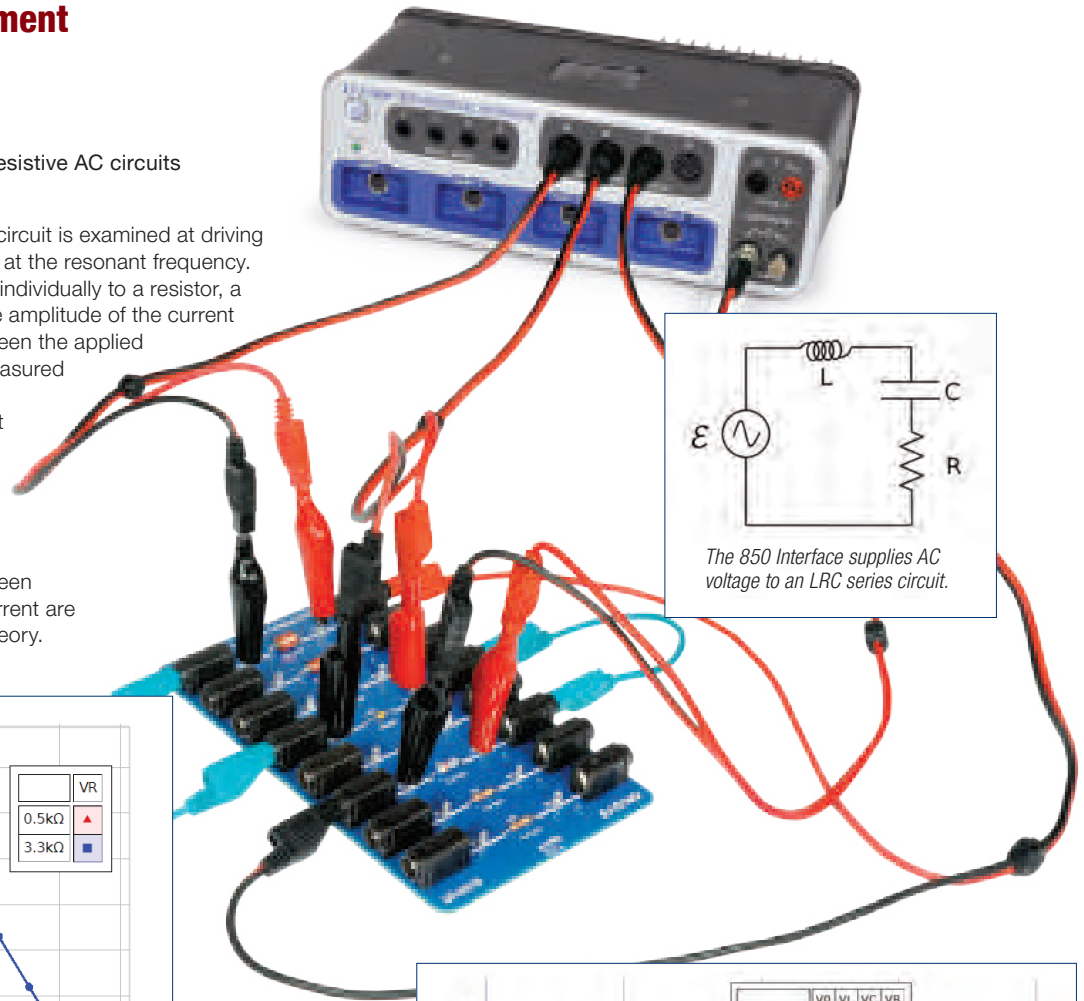
The effect of circuit resistance on peak width is clear and leads to an understanding of how to design a filter for a circuit.

Includes:

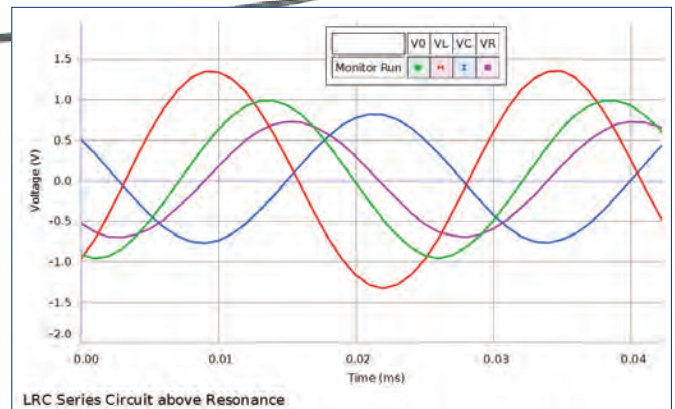
- Resistor Capacitor Inductor Network UI-5210
- Voltage Sensors (unshrouded) (3) UI-5100
- Banana Plug Cord Sets, 30 cm Length (8) SE-7123
- BNC Function Generator Output Cable (unshrouded) UI-5119

Download This Experiment

The FREE experiment files include a pdf of the student instructions and a PASCO Capstone™ workbook file. Download this experiment at pasco.com/CapstoneExperiments.



The 850 Interface supplies AC voltage to an LRC series circuit.



The oscilloscope display in PASCO Capstone is used to simultaneously display the voltages across the inductor, capacitor, and resistor, as well as the source voltage.

Order Information

LRC Circuit Experiment	EX-5537
Required:	
550 or 850 Universal Interface	pp. 20-23
PASCO Capstone Software	pp. 8-11

Electromagnetism

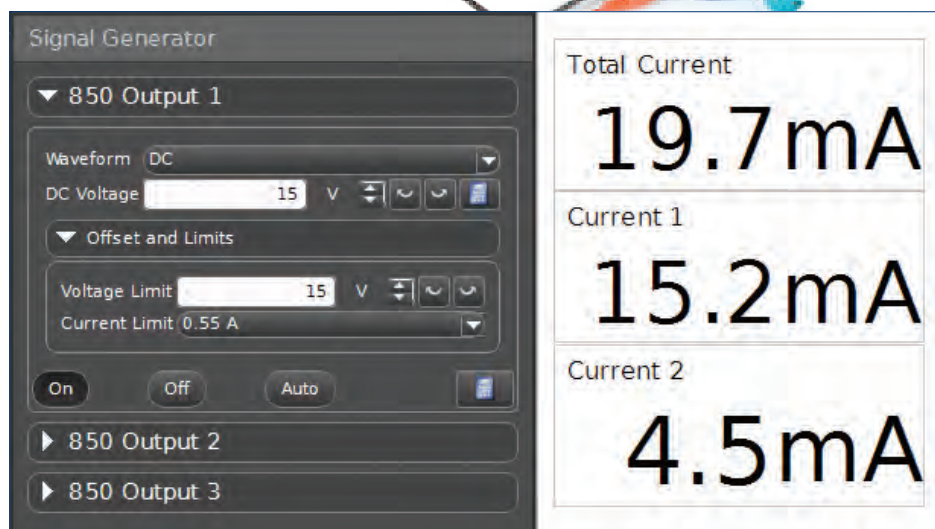
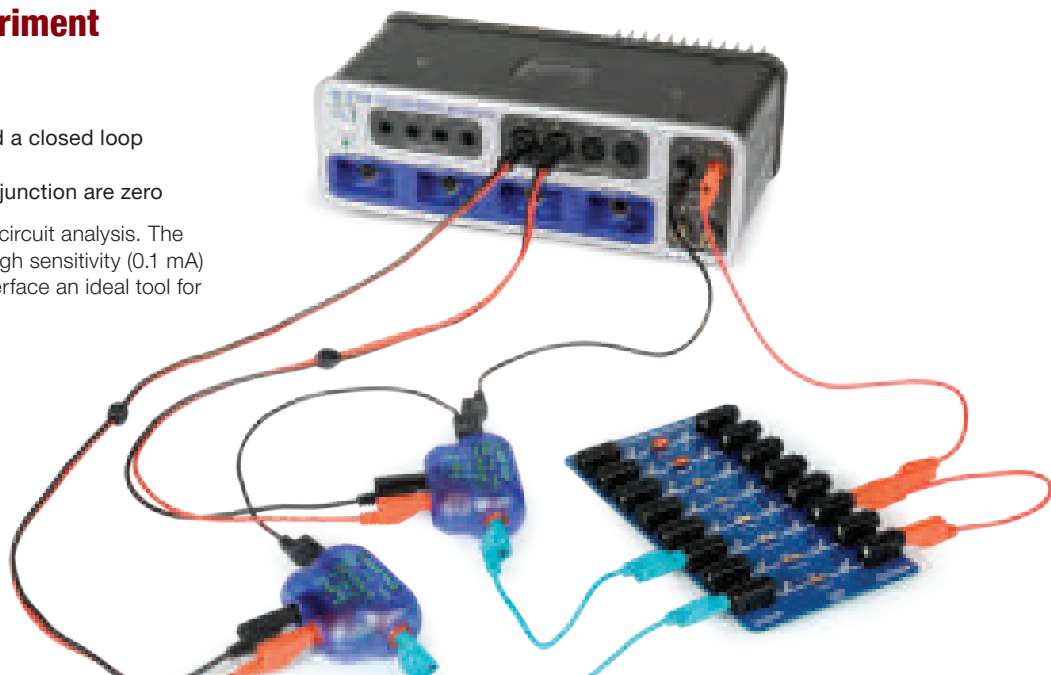
Kirchhoff's Rules Experiment

EX-5538

Concepts:

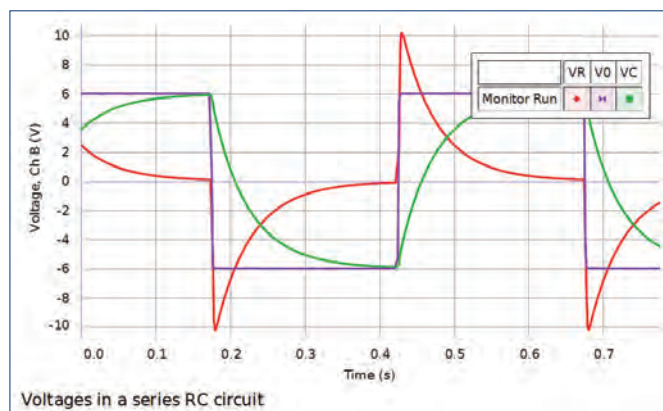
- Summation of the voltages around a closed loop are zero at any instant
- Summation of the currents at any junction are zero

Kirchhoff's Laws form the basis of all circuit analysis. The high speed for AC applications and high sensitivity (0.1 mA) for DC applications make the 850 Interface an ideal tool for investigating AC and DC circuits.



Measurement of voltages and currents in series-parallel DC circuits demonstrates the validity of Kirchhoff's Laws. The use of multiple current probes avoids student confusion that can arise when rearranging the circuit to measure currents at different points.

Students control output from the 850 signal generators directly from the user interface in PASCO Capstone. Students compare the current flow through each resistor to the total current output from the 850.



The high speed of the 850 Universal Interface, in scope mode, allows the examination of time varying voltages in an RC circuit to verify that Kirchhoff's loop theorem holds even when voltage is not constant.

Includes:

- Resistor Capacitor Inductor Network UI-5210
- Voltage Sensors (unshrouded) (3) UI-5100
- PASPORT Current Probes (2) PS-2184
- Banana Plug Cord Sets, 30 cm length (8) SE-7123

Download This Experiment

The FREE experiment files include a pdf of the student instructions and a PASCO Capstone™ workbook file. Download this experiment at pasco.com/CapstoneExperiments.

Order Information

Kirchhoff's Rules Experiment EX-5538

Required:

550 or 850 Universal Interface pp. 20-23

PASCO Capstone Software pp. 8-11

Magnetic Force on a Current-Carrying Wire

EX-5568

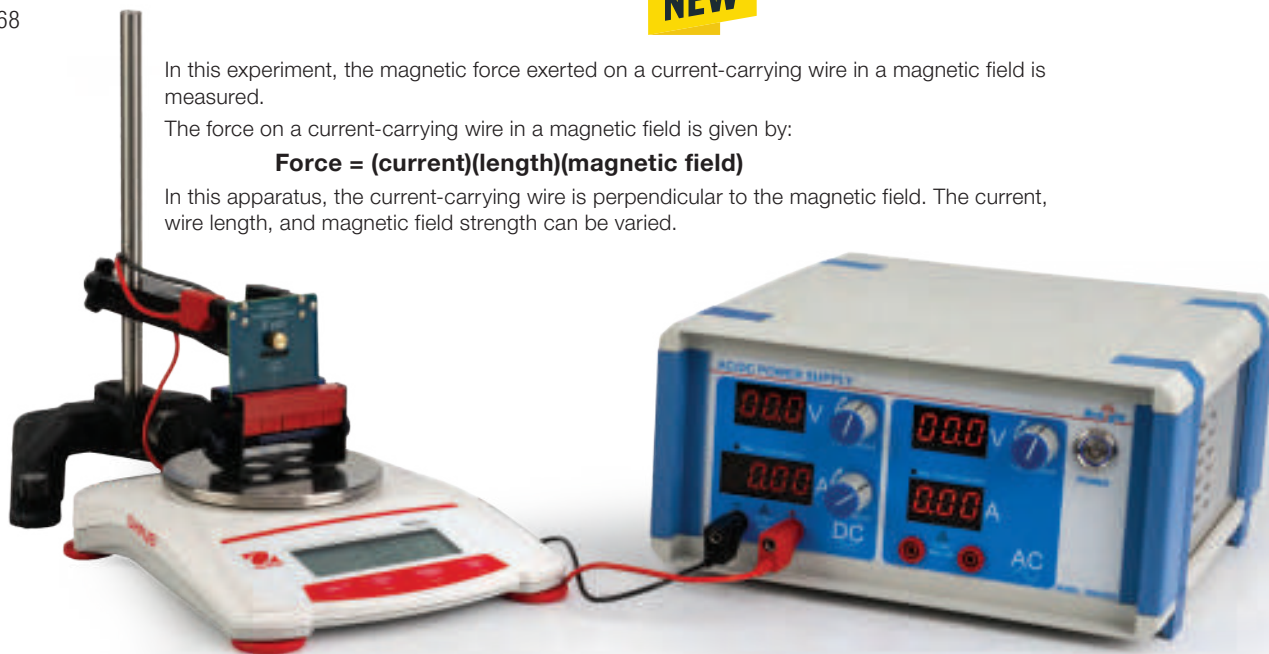
NEW

In this experiment, the magnetic force exerted on a current-carrying wire in a magnetic field is measured.

The force on a current-carrying wire in a magnetic field is given by:

$$\text{Force} = (\text{current})(\text{length})(\text{magnetic field})$$

In this apparatus, the current-carrying wire is perpendicular to the magnetic field. The current, wire length, and magnetic field strength can be varied.



A wire of a certain length (mounted on a circuit board) is positioned between the poles of a horseshoe magnet, resting on a mass balance. When a current runs through the wire, the force of the current on the magnet registers on the balance.

In Part I, the current is varied while the wire length and the magnetic field are held constant. In Part II, the length of the wire in the magnetic field is varied while the current and the magnetic field are held constant. In Part III, the magnetic field is varied while the current and the wire length are held constant.

There are four different length wires (2 cm, 3 cm, 4 cm, and 5 cm), each mounted on a separate circuit board, so the relationship between wire length and magnetic force can be determined.

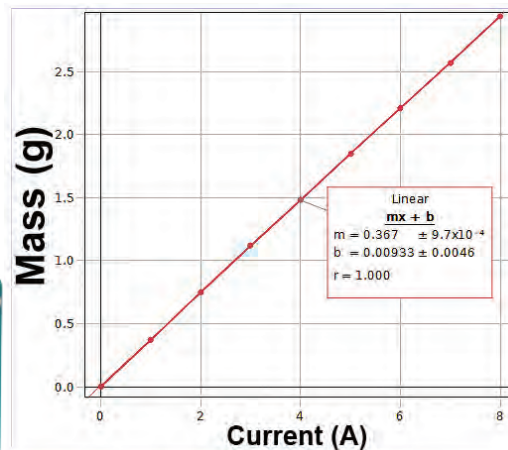
The magnetic field strength can be varied by removing each of the five horseshoe magnets one by one. The magnetic field remains uniform across the length of the wire because of the pole pieces in the magnet holder. The magnetic field strength can be measured with a Wireless Magnetic Field Sensor (PS-3221).

Topics Covered:

- ▶ How the resulting force experienced by the magnet depends on the current through the wire.
- ▶ How the dependence of the resulting force experienced by the magnet depends on the length of a current-carrying wire.
- ▶ How the resulting force experienced by the magnet depends on the magnetic field strength.

Includes:

- | | |
|-----------------------------------|----------|
| • Current Balance | EM-8607 |
| • AC/DC Power Supply | SE-9584 |
| • Wireless Magnetic Field Sensor | PS-3221 |
| • Small A-Base with Leveling Feet | ME-8989 |
| • Stainless Steel Rod, 45 cm | ME-8736 |
| • Ohaus Scout SKX Balance 420g | SE-8756B |
| • 2-meter Shrouded Patch Cord Set | |



The mass read on the balance versus the current through the wire.

Download This Experiment

The FREE experiment files include a pdf of the student instructions and a PASCO Capstone™ workbook file. Download this experiment at pasco.com/CapstoneExperiments.

Order Information

Magnetic Force on a
Current-Carrying Wire..... EX-5568
(No interface required.)

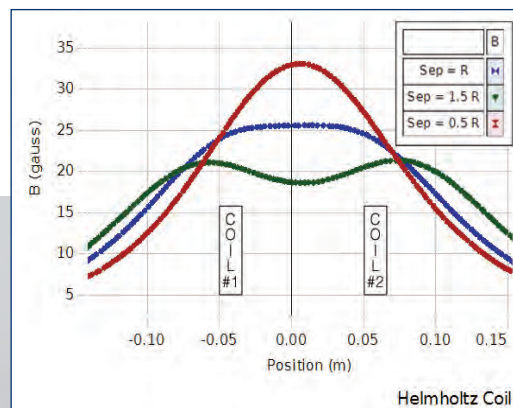
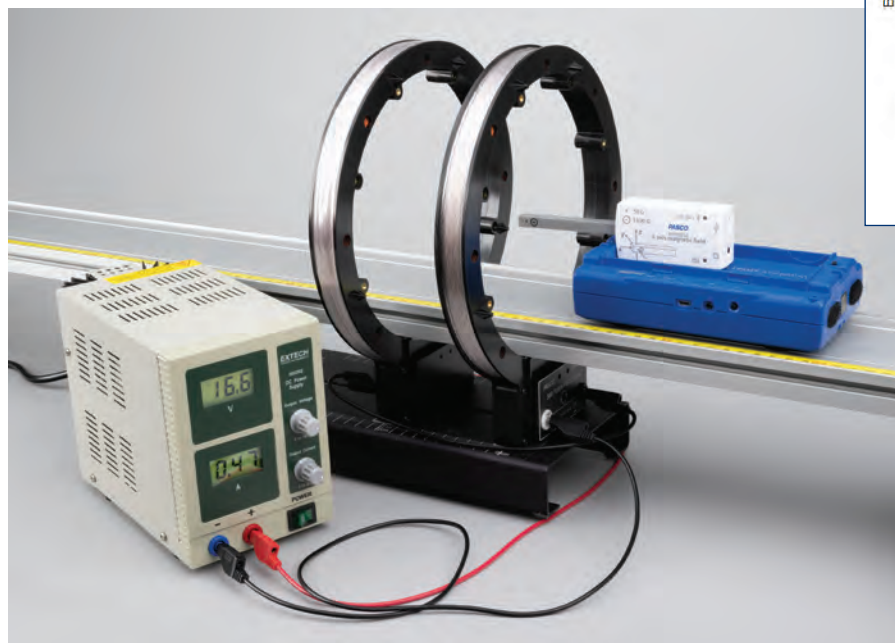
Electromagnetism

Magnetic Fields of Coils Experiment

EX-5640

Concepts:

- Magnetic fields of single coil, Helmholtz coils, and inside a solenoid



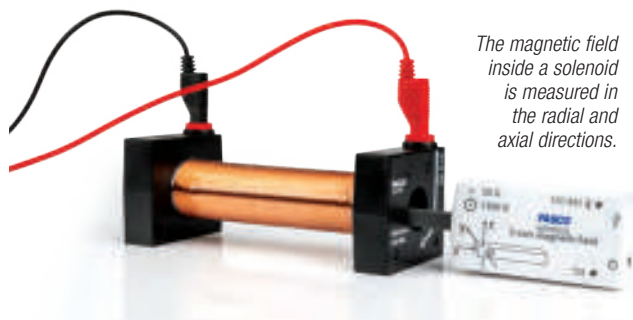
This plot shows the magnetic field strength along the axis of Helmholtz coils for three different coil separations. The blue data was collected using coils with the proper separation (the coil radius); the red data was collected using coils that were too close together; and the green data was collected from coils that were too far apart.

The magnetic field of Helmholtz coils is measured as a function of distance along the perpendicular axis.

The dependence of the magnetic field strength of current-carrying coils on the distance from the coil along the perpendicular axis is determined and compared to the theoretical curve. In addition, the effect of varying the coil separation on the shape of the magnetic field between the Helmholtz coils is examined.

To perform the experiment, a Wireless Magnetic Field Sensor is mounted to a Smart Cart and placed on a track with coils. As the cart passes through the coils, a real-time plot of the magnetic field strength vs. position is created.

It is particularly interesting to compare the field from Helmholtz coils properly separated by the coil radius to the field from coils separated at less than or more than the coil radius. The magnetic field inside a solenoid can be examined in both the radial and axial directions.



PASCO Advantage:

When used with the Wireless Magnetic Field Sensor, the Smart Cart's built-in position sensor makes it easy to pair magnetic field measurements with precise position data.

Download This Experiment

The FREE experiment files include a pdf of the student instructions and a PASCO Capstone™ workbook file. Download this experiment at pasco.com/CapstoneExperiments.

Includes:

- | | |
|-----------------------------------|----------|
| • Helmholtz Coil Base | EM-6715 |
| • 500-Turn Field Coils (2) | EM-6723A |
| • Primary and Secondary Coils | EM-6709 |
| • Banana Plug Cord-Red (5 pack) | SE-9750 |
| • Banana Plug Cord-Black (5 pack) | SE-9751 |
| • Dynamics Track | ME-9493 |
| • Student Power Supply | SE-8828 |
| • Round Base with Rod (2 of each) | ME-8270 |
| • Track Rod Clamp (2) | ME-9836 |
| • Wireless Magnetic Field Sensor | PS-3221 |
| • Wireless Smart Cart (blue) | ME-1241 |

Order Information

Magnetic Fields of Coils Experiment..... EX-5640

Required:

PASCO Capstone Software pp. 8-11

View the 550 or 850 Universal Interface-compatible version of this experiment (EX-5540A) online at pasco.com/capstoneexperiments

Ampere's Law

EX-5552

Concepts:

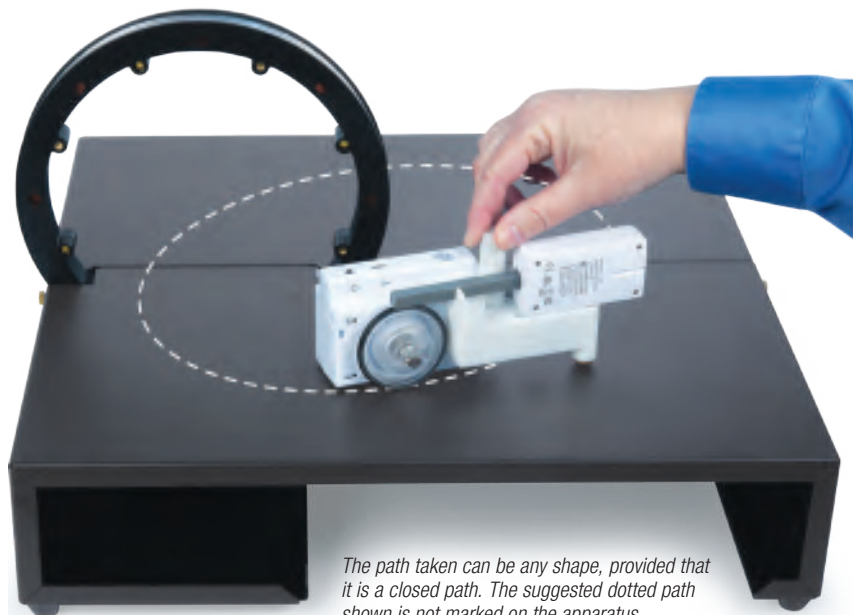
- Verify Ampere's Law
- Plot magnetic field tangent to path
- Closed integral is area under B vs. Distance plot
- Choose to enclose current in path or not

Students can verify Ampere's Law experimentally by graphing the magnetic field strength that is tangent to the path taken along a closed path that encloses a current source.

The magnetic field strength is measured with a Wireless Magnetic Field Sensor which rides on a Rotary Motion Sensor. The student pushes the Rotary Motion Sensor, which rolls on its wheel along a closed path.

PASCO Advantage:

The Wireless 3-Axis Magnetic Field and 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; a circular path is unnecessary because the sensors are recording the field tangent to any path.



The path taken can be any shape, provided that it is a closed path. The suggested dotted path shown is not marked on the apparatus.

$$\oint \vec{B} \cdot d\vec{l} = \mu_0 NI$$

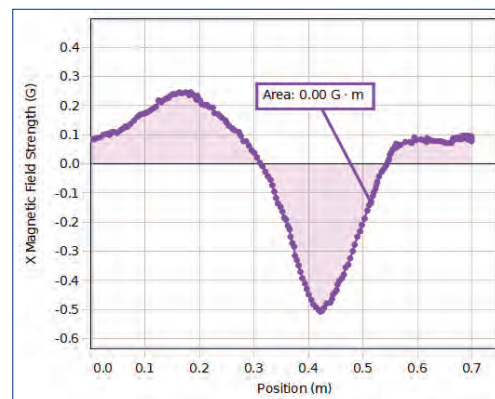
Area under B vs. Distance curve = μ_0 (# of coil turns enclosed in path) (Current)

The key to making this work is that the Magnetic Field Sensor element is positioned tangent to the Rotary Motion Sensor's wheel. This accomplishes the dot product in Ampere's Law because only the component of the magnetic field that is tangent to the path is recorded.

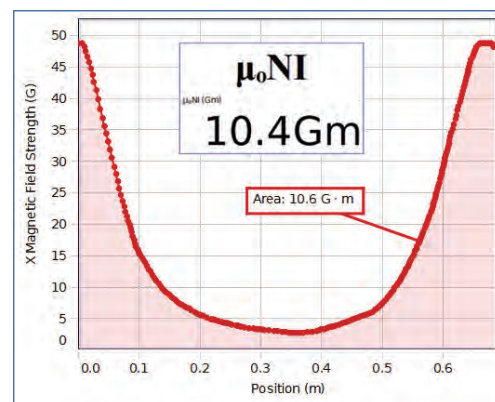
If you traverse a path that does not enclose any current source, the area under the curve is zero. The magnetic field of the Earth or any nearby source is measured, but they cancel out in a closed loop that encloses no current.

Includes:

- | | |
|----------------------------------|----------|
| • Ampere's Law Accessory | EM-6720 |
| • Wireless Magnetic Field Sensor | PS-3221 |
| • Wireless Rotary Motion Sensor | PS-3220 |
| • 500-Turn Field Coil | EM-6723A |
| • Zero Gauss Chamber | EM-8652 |



No current enclosed: Area is zero.



Current enclosed: Area is $\mu_0 NI$.

Download This Experiment

The FREE experiment files include a pdf of the student instructions and a PASCO Capstone™ workbook file. Download this experiment at pasco.com/CapstoneExperiments.

Order Information

Ampere's Law	EX-5552
Required:	
PASCO Capstone Software.....	pp. 8-11
(No interface required.)	

Electromagnetism

Faraday's Law of Induction Experiment

EX-5641

Concepts:

- ▶ Magnetic flux
- ▶ Faraday's Law of Induction
- ▶ Lenz's Law
- ▶ Conservation of energy
- ▶ Electrical power

A voltage is induced in a coil swinging through a magnetic field. Faraday's Law and Lenz's Law are examined, and the energy dissipated in a load resistor is compared to the loss of energy of the coil pendulum.

A rigid pendulum with a coil at its end swings through a horseshoe magnet. A resistive load is connected across the coil, and the induced voltage is recorded using a Wireless Voltage Sensor. The angle is measured with a Wireless Rotary Motion Sensor, which also acts as a pivot for the pendulum. The induced voltage is plotted vs. time and angle. The power dissipated in the resistor is calculated from the voltage, and the energy converted to thermal energy is determined by finding the area under the Power vs. Time curve. This energy is compared to the loss of energy determined from the amplitude and the speed of the pendulum.

Faraday's Law is used to estimate the magnetic field of the magnet from the maximum induced voltage. Additionally, the direction of the induced voltage as the coil enters and leaves the magnetic field is examined and analyzed using Lenz's Law.

PASCO Advantage:

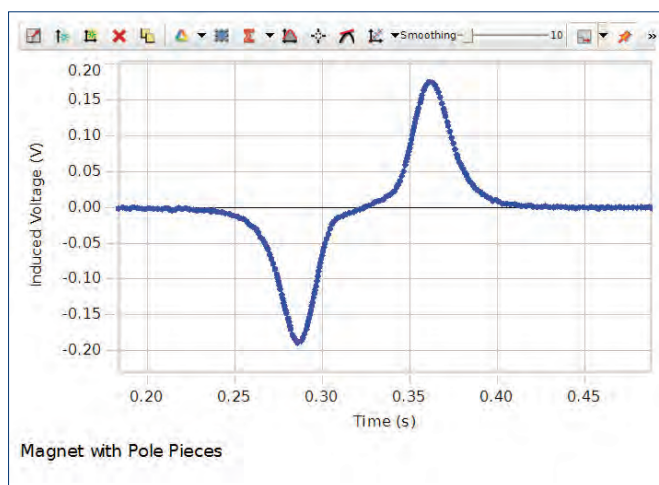
Students can use PASCO Capstone™ to calculate energy and power from the voltage and angle data. The induced voltage and calculations are plotted in real time as the coil swings through the magnet.

Includes:

- | | |
|----------------------------------|----------|
| • Induction Wand | EM-8099 |
| • Large Rod Base | ME-8735 |
| • 45 cm Stainless Steel Rods (2) | ME-8736 |
| • Multi-Clamp | ME-9507 |
| • Wireless Voltage Sensor | PS-3211 |
| • Wireless Magnetic Field Sensor | PS-3221 |
| • Wireless Rotary Motion Sensor | PS-3220 |
| • Variable Gap Magnet | EM-8618 |
| • 2-Meter Patch Cord Set | SE-9415A |

Download This Experiment

The FREE experiment files include a pdf of the student instructions and a PASCO Capstone™ workbook file. Download this experiment at pasco.com/CapstoneExperiments.



Plot of induced voltage as coil swings through the magnet.

Order Information

Faraday's Law of Induction Experiment..... EX-5641

Required:

PASCO Capstone Software pp. 8-11

View the 550 or 850 Universal Interface-compatible version of this experiment (EX-5541A) online at pasco.com/capstoneexperiments

Ferromagnetic Hysteresis

EX-5566

NEW



Study the hysteresis plot for a ferromagnetic core in a transformer. A varying magnetic field is generated in a transformer iron core by applying a triangle wave voltage to the primary coil. The magnetic flux density, B , is plotted versus the magnetic field strength, H . From this hysteresis plot, the value of B at saturation is determined, as well as the retentivity and coercivity of the ferromagnetic core.

To determine the magnetic flux density in the core, the voltage across the secondary coil is measured and plotted versus time. Using Faraday's Law of Induction, the area under the voltage versus time curve is the integral of the induced emf, which is proportional to the magnetic flux density.

The magnetic field strength is determined by measuring the input current to the primary coil.

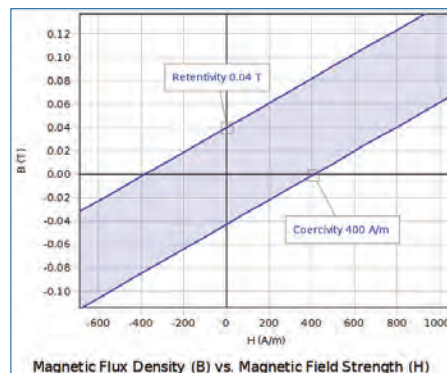
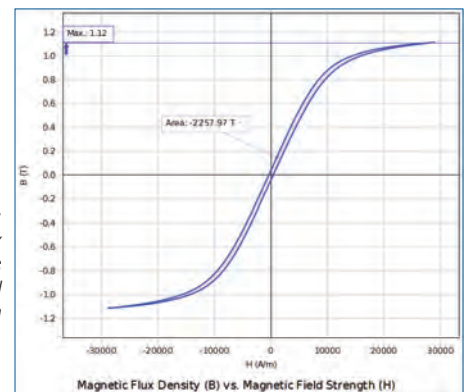
Students analyze the B versus H plot to find:

- The area inside the curve is a measure of the energy/volume lost per cycle.
- The retentivity is the amount of magnetic flux density that the material retains when there is no current in the coils.
- The coercivity is the amount of reverse magnetic field strength that is required to make the magnetic flux density zero again.

Includes:

- | | |
|-----------------------------------|---------|
| • Transformer Coil (800 turn) (2) | EM-8611 |
| • Transformer Core | EM-8614 |
| • Shrouded Red Patch Cords | EM-9740 |
| • Shrouded Black Patch Cords | EM-9745 |
| • Voltage Sensor (shrouded) | UI-5110 |

*Hysteresis curve:
Magnetic Flux
Density versus
Magnetic Field
Strength*



*Close-up of center
of hysteresis
curve showing
the retentivity and
coercivity.*

Download This Experiment

The FREE experiment files include a pdf of the student instructions and a PASCO Capstone™ workbook file. Download this experiment at pasco.com/CapstoneExperiments.

Order Information

Ferromagnetic Hysteresis EX-5566
Required:
PASCO Capstone Software pp. 8-11

Waves and Optics

Mechanical Waves Experiment

EX-9952

Concepts:

- Speed of waves in a string
- Resonance in strings and air columns
- Speed of sound in air
- Harmonics



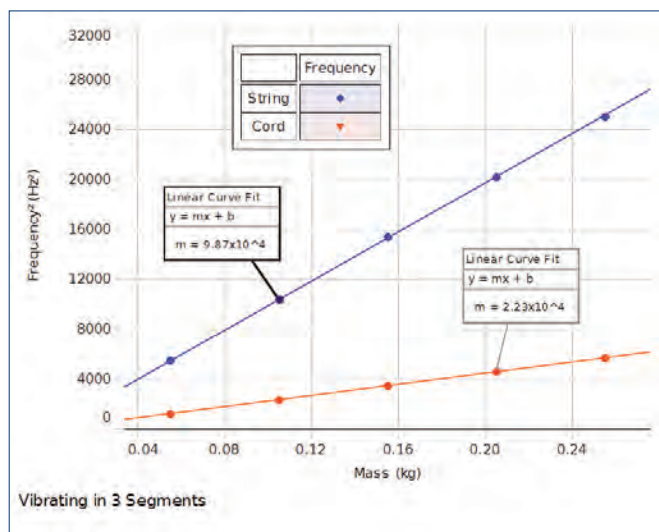
Use this experiment to study standing waves in strings and air columns. Using a Sine Wave Generator to drive a String Vibrator, the driving frequency, length, density, and tension of the string are varied to explore standing waves in strings and to determine the speed of the wave. To produce sound waves in the air column, a speaker is used to drive a resonance tube. The driving frequency and the length of the tube are varied for both open and closed tubes. The relationship between resonant frequency modes and tube length is determined for both closed and open tubes.

PASCO Advantage:

The frequency of the vibration of the string is not limited to the line frequency, so the frequency can be varied as well as the length and the tension.

Includes:

- String Vibrator WA-9857A
- Sine Wave Generator WA-9867
- Open Speaker WA-9900
- Economy Resonance Tube WA-9495
- Elastic Wave Cord SE-9409
- Braided Physics String SE-8050
- Mass and Hanger Set ME-8979
- Universal Table Clamp (2) ME-9376B
- Adjustable Angle Clamp ME-8744
- Super Pulley ME-9450A
- Pulley Mounting Rods SA-9242
- 45 cm Stainless Steel Rod (2) ME-8736
- Banana Plug Cord-Red (5 pack) SE-9750
- Waves Experiment Manual



Graphs of the square of the frequency vs. the hanging mass for two different types of strings have different slopes corresponding to different string densities.

Download This Experiment

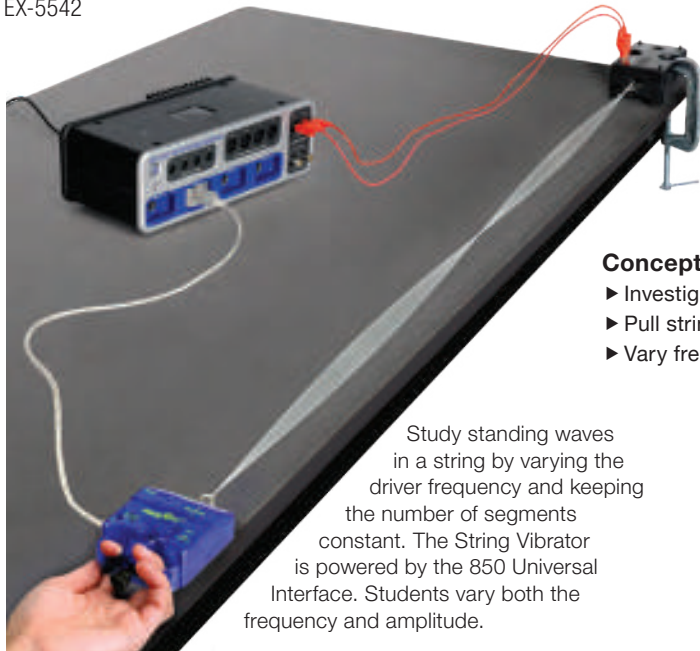
Search for EX-9952 at pasco.com

Order Information

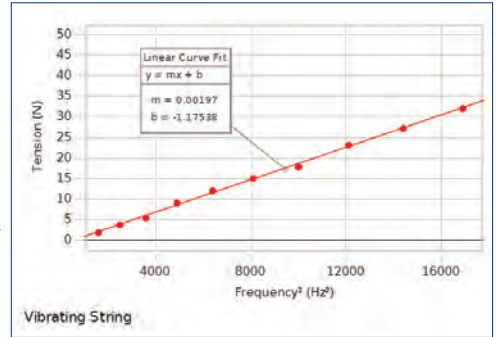
Mechanical Waves Experiment..... EX-9952
(No interface required.)

Vibrating Strings Experiment

EX-5542



The string tension is measured directly with a Force Sensor, enabling students to feel the force required to obtain a certain number of segments.



Concepts:

- Investigate standing waves
- Pull string to adjust number of segments
- Vary frequency of vibration

Study standing waves in a string by varying the driver frequency and keeping the number of segments constant. The String Vibrator is powered by the 850 Universal Interface. Students vary both the frequency and amplitude.

Includes:

- String Vibrator WA-9857A
- Braided Physics String SE-8050
- PASPORT High Resolution Force Sensor PS-2189
- Large "C" Clamp
- Banana Plug Cord-Red (5 pack) SE-9750
- 30 Meter Measuring Tape SE-8712A

Order Information

Vibrating Strings Experiment..... EX-5542

Required:

550 or 850 Universal Interface..... pp. 20-23

PASCO Capstone Software..... pp. 8-11

Download This Experiment

The FREE experiment files include instructions in Microsoft Word®, PASCO Capstone™ workbook files with sample data, and graphics. Download these experiments at www.pasco.com/CapstoneExperiments.

Sound of Vibrating Strings Experiment

EX-5565

Concepts:

- How Frequency Depends on String Tension
- How Frequency Depends on String Length
- How Frequency Depends on String Linear Density

Examine how tension and string length affect the sound of a vibrating string.

First, the length of the vibrating string is varied, and the tone is observed. Then the frequency of the sound is measured with the Wireless Sound Sensor, and the relationship between string length and frequency is determined.

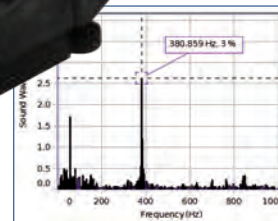
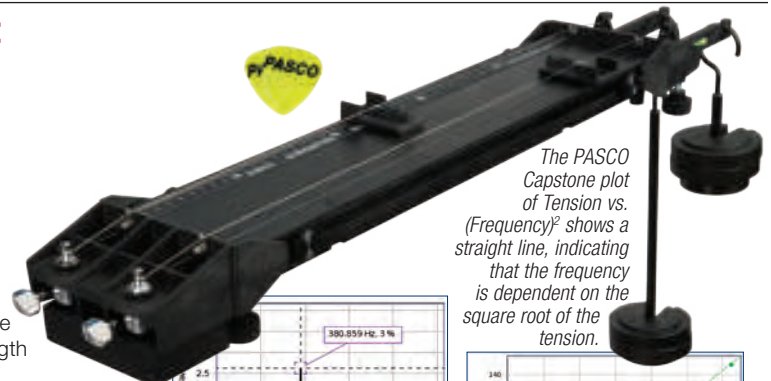
Next, the tension in the vibrating string is varied, and the tone is observed. The frequency is measured and the relationship between the string tension and the frequency is determined.

Finally, the frequencies of two strings of the same length and tension but different linear densities are compared.

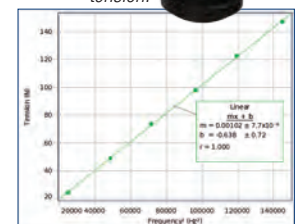
For a given string tension, the length of a string is adjusted until each tuning fork in the set causes the string to resonate. The vibrating tuning fork is held against the Sonometer sounding board, and when the resonant frequency of the string matches the frequency of the tuning fork, the paper riders on the string will vibrate. The relationship between the frequencies and the length is determined.

Includes:

- Sonometer WA-7428
- Wireless Sound Sensor PS-3227
- Tuning Fork Set SE-7342
- Large Slotted Mass Set ME-7566
- Short Mass Hanger ME-7590



The frequency of the sound can be determined using a Sound Sensor and the FFT in PASCO Capstone.



Download This Experiment

The FREE experiment files include a pdf of the student instructions and a PASCO Capstone™ workbook file. Download this experiment at pasco.com/CapstoneExperiments.

Order Information

Sound of Vibrating Strings Experiment..... EX-5565

Required:

PASCO Capstone Software..... pp. 8-11
(No interface required.)

Waves and Optics

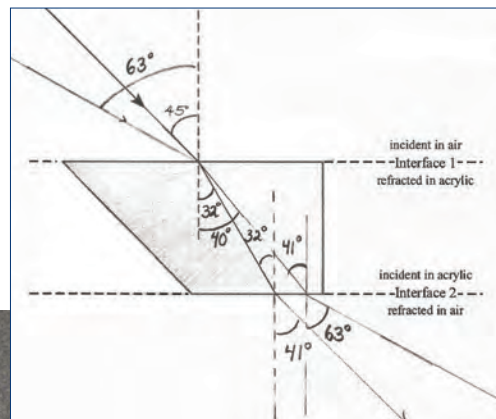
Reflection and Refraction

EX-9987

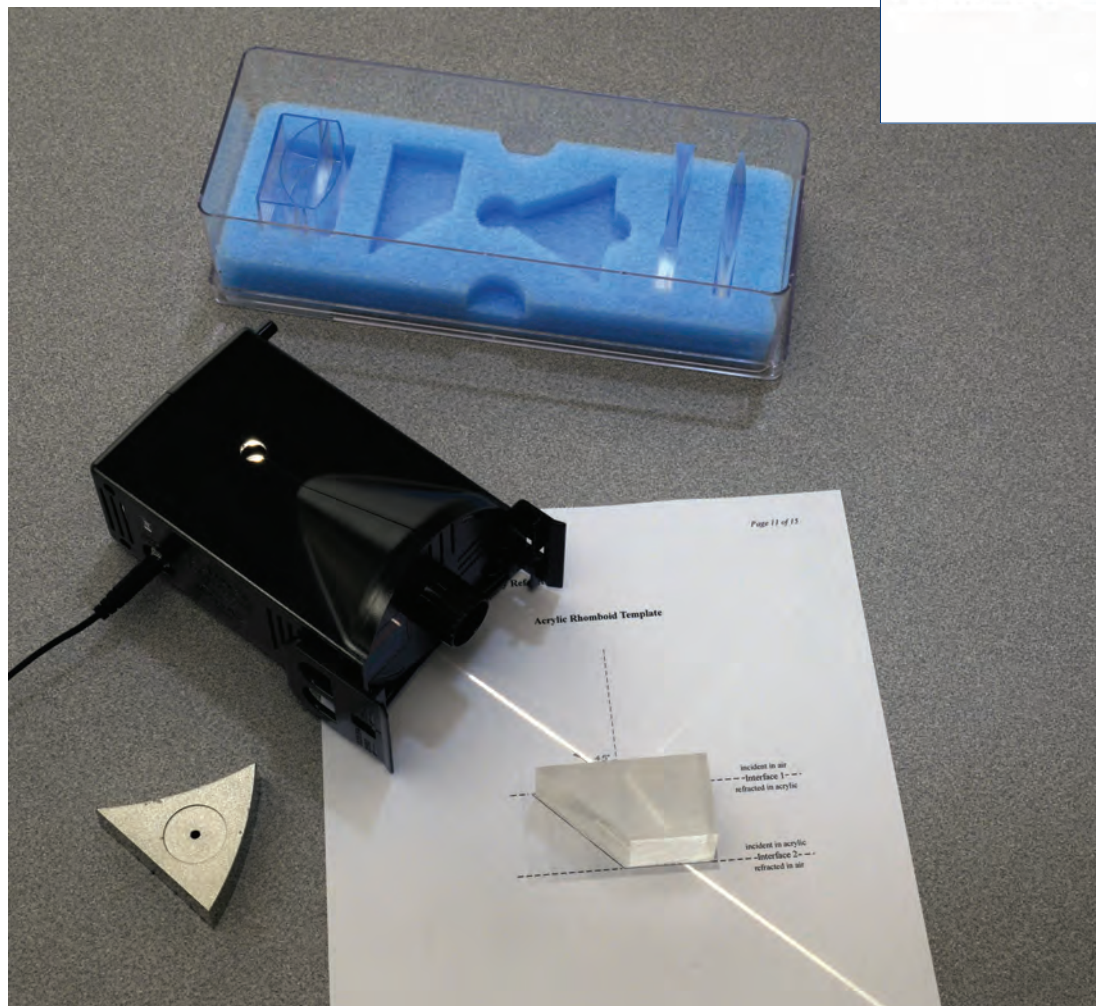
Concepts:

- Reflection and Refraction
- Index of Refraction

Students experimentally derive the Law of Reflection for curved and flat mirrors. Snell's Law is explored and the index of refraction for a piece of acrylic material is found.



Sample of student work, showing the path of two different rays passing through the acrylic rhomboid.



PASCO Advantage:

Students trace the rays on the provided templates and make angle measurements directly from their drawings. This reinforces the connection between the real rays they can see in the lab and the type of ray diagrams seen in the classroom.

Includes:

- Ray Optics Kit OS-8516A
- Basic Optics Light Source OS-8470
- Reflection and Refraction Experiment Manual

Download This Experiment

Search for EX-9987 at [pasco.com](https://www.pasco.com)

Order Information

Reflection and Refraction..... EX-9987
 Required:
 Protractor and Ruler

Telescope/Microscope

EX-9988

Topics Covered:

- Multiple Lens Systems
- Parallax
- Magnification
- Description of Images

Students construct an astronomical telescope, a Galilean telescope, and a compound microscope on the optical bench. Using a viewing screen with grid, they find and describe the ways in which images are changed by the multiple lens systems.

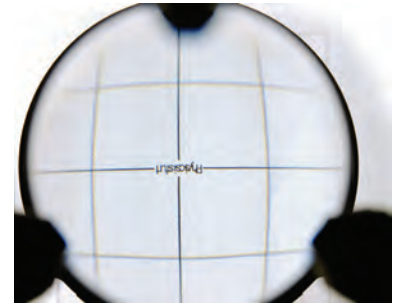
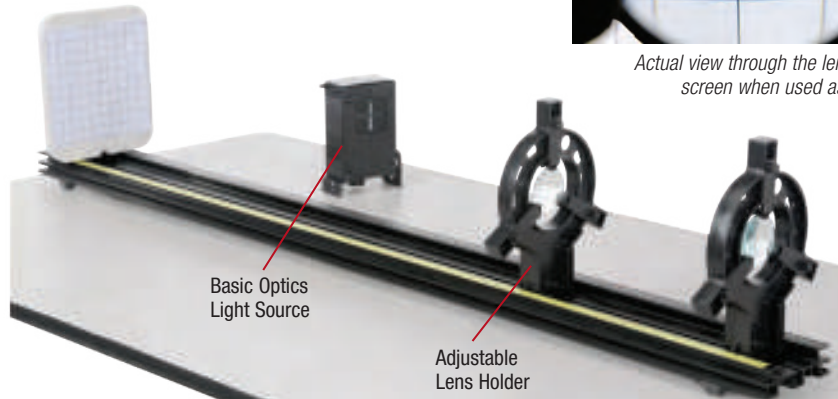
The parallax method is used to locate virtual images. Students draw ray diagrams and measure the magnification of the instruments.

PASCO Advantage:

Using the Basic Optics Track and Adjustable Lens Holders makes it easy for students to quickly build each of the instruments. The open construction allows all students to see the location and types of lenses used.

Includes:

- Basic Optics Light Source OS-8470
- Adjustable Lens Holder OS-8474
- Geometric Lens Set OS-8466A
- Basic Optics Viewing Screen OS-8460
- 1.2 m Optics Track OS-8508



Actual view through the lens of magnified screen when used as a microscope

Download This Experiment

Search for EX-9988 at www.pasco.com

Order Information

Telescope/Microscope EX-9988

Required:

Rubber Bands and Ruler

Light Intensity vs. Distance Experiment

EX-5547A

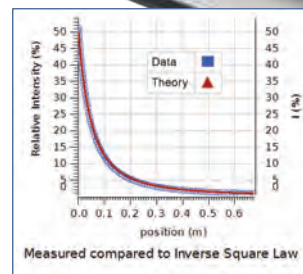
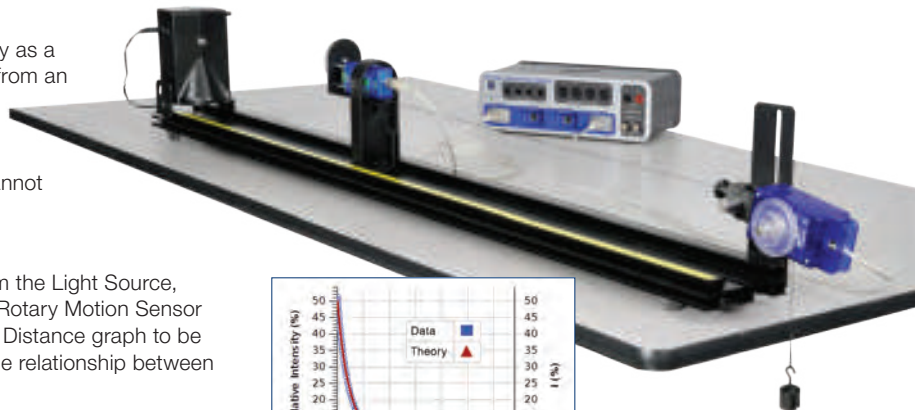
In this experiment the student measures intensity as a function of distance from a point of source and from an extended (5 cm x 5 cm) source. Manipulation of a computer model verifies that for the point source, the intensity drops off like an inverse square. But for the extended source the data cannot be fit by an inverse square relationship.

PASCO Advantage:

As the student slides the Light Sensor away from the Light Source, the Optics Track keeps everything aligned. The Rotary Motion Sensor measures the position, allowing the Intensity vs. Distance graph to be plotted in real time. Students immediately see the relationship between distance and intensity of light.

Includes:

- 1.2 m Optics Track OS-8508
- Basic Optics Light Source OS-8470
- Aperture Bracket OS-8534A
- Hooked Mass Set SE-8759
- PASPORT High Sensitivity Light Sensor PS-2176
- PASPORT Rotary Motion Sensor PS-2120A
- Dynamics Track Mount CI-6692



Order Information

Light Intensity vs. Distance Experiment EX-5547A

Required:

550 or 850 Universal Interface* pp. 20-23

PASCO Capstone Software pp. 8-11

* This experiment can be performed using the 550 or 850 Universal Interface or any PASPORT interface with two ports.

Download This Experiment

The FREE experiment files include a pdf of the student instructions and a PASCO Capstone™ workbook file. Download this experiment at pasco.com/CapstoneExperiments.

Waves and Optics

Interference and Diffraction of Light Experiment

EX-5645

Concepts:

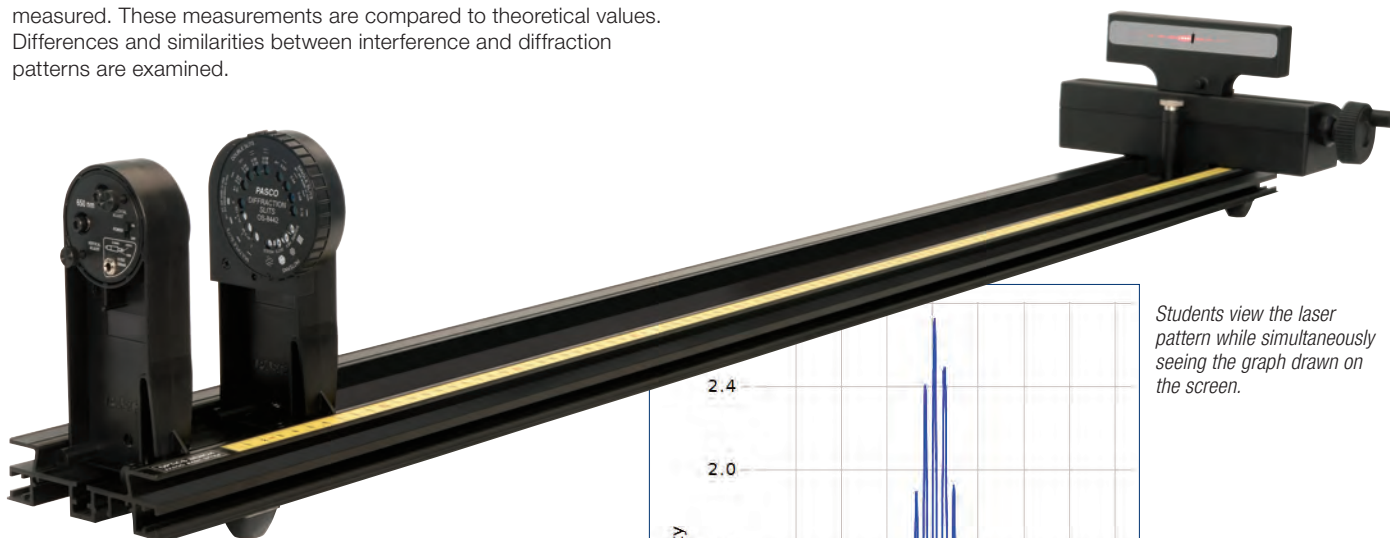
- ▶ Two-slit interference
- ▶ Single-slit diffraction
- ▶ Multiple-slit minor maxima

Interference and diffraction patterns from laser light passing through various single-slits and multiple-slits are scanned and plotted in real time. These patterns are then examined for similarities and differences. The effect of wavelength is studied using red and green lasers.

The distances between the central maximum and the diffraction minima for a single slit are measured by scanning the laser pattern with a Light Sensor and plotting Light Intensity vs. Distance. Then, the distances between interference maxima for two or more slits are measured. These measurements are compared to theoretical values. Differences and similarities between interference and diffraction patterns are examined.



The laser interference pattern is scanned by turning the crank.



PASCO Advantage:

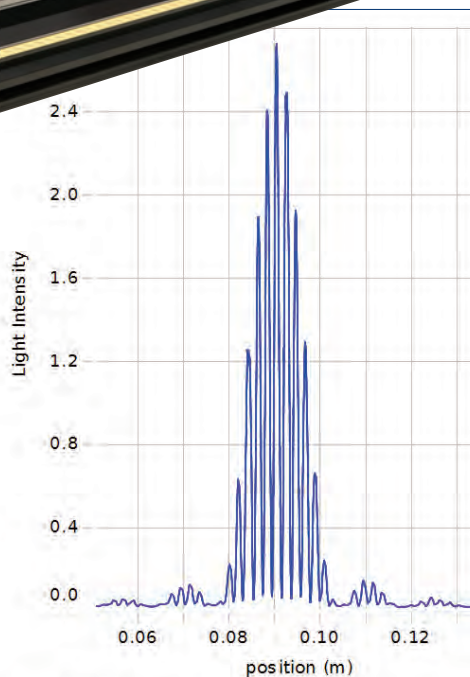
Easily select a different slit pattern by rotating the slit disk. Several single-slit and multiple-slit options are provided for comprehensive analysis.

Includes:

- 1.2 m Optics Track OS-8508
- Diffraction Slits OS-8442
- Red Diode Laser OS-8525A
- Green Diode Laser OS-8458B
- Wireless Diffraction Scanner OS-8441

Download This Experiment

The FREE experiment files include a pdf of the student instructions and a PASCO Capstone™ workbook file. Download this experiment at pasco.com/CapstoneExperiments.



Double Slit Interference

Students view the laser pattern while simultaneously seeing the graph drawn on the screen.

A computer scan of a double-slit interference pattern (slit width 0.08 mm and slit separation 0.50 mm) is shown at left.

Order Information

Interference and Diffraction of Light Experiment..... EX-5645

Required:

PASCO Capstone Software..... pp. 8-11

View the 550 or 850 Universal Interface-compatible version of this experiment (EX-5545A) online at pasco.com/capstoneexperiments

Polarization Experiment

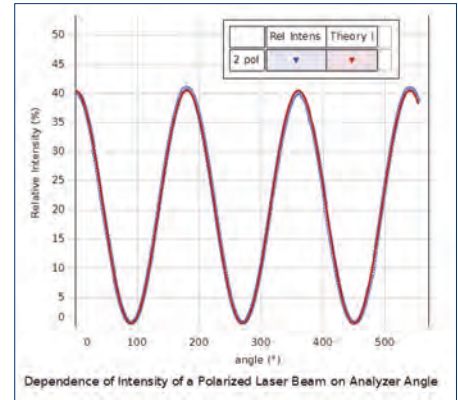
EX-5543A

Concepts:

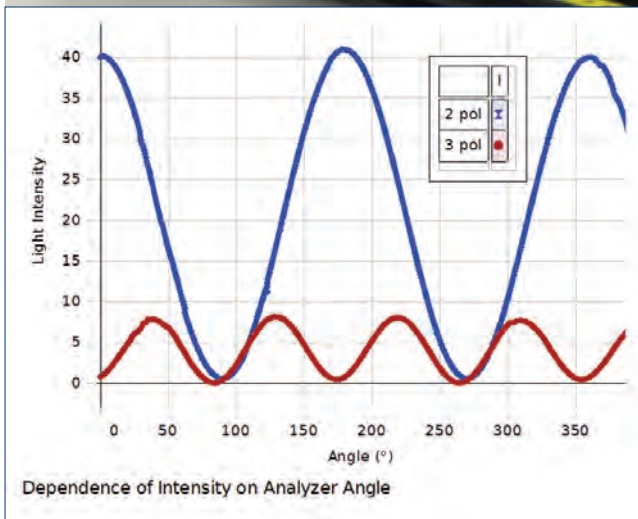
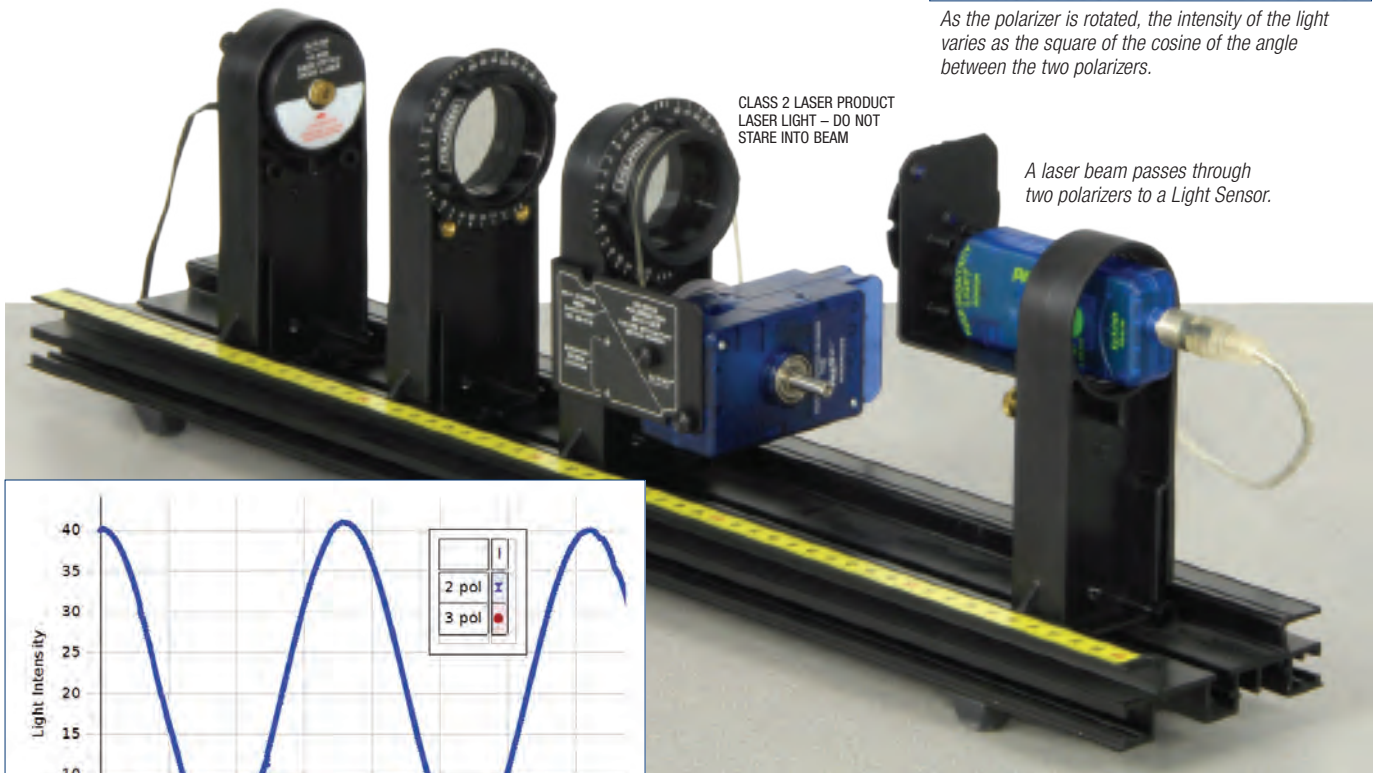
► Malus' Law of Polarization

In this experiment, Malus' Law of Polarization is verified by showing that the intensity of light passed through two polarizers depends on the square of the cosine of the angle between the two polarization axes.

Laser light (peak wavelength = 650 nm) is passed through two polarizers. As the second polarizer (the analyzer) is rotated by hand, the relative light intensity is recorded as a function of the angle between the axes of polarization of the two polarizers. The angle is obtained using a Rotary Motion Sensor coupled to the polarizer with a drive belt. The plot of light Intensity vs. Angle can be fitted to the square of the cosine of the angle.



As the polarizer is rotated, the intensity of the light varies as the square of the cosine of the angle between the two polarizers.



The laser's polarization can be used to produce a three-polarizer system. The data (red trace) at left shows that there are four oscillations per full rotation for a three-polarizer system.

PASCO Advantage:

Laser light is used in this experiment because its wavelength is more completely extinguished by the crossed polarizers.

Includes:

- Polarization Analyzer OS-8533A
- Optics Benches (60 cm) OS-8541
- Red Diode Laser OS-8525A
- PASPORT High Sensitivity Light Sensor PS-2176
- PASPORT Rotary Motion Sensor PS-2120A

Download This Experiment

The FREE experiment files include a pdf of the student instructions and a PASCO Capstone™ workbook file. Download this experiment at pasco.com/CapstoneExperiments.

Order Information

Polarization Experiment EX-5543A

Required:

550 or 850 Universal Interface* pp. 20-23

PASCO Capstone Software pp. 8-11

* This experiment can be performed using the 550 or 850 Universal Interface or any PASPORT interface with two ports.

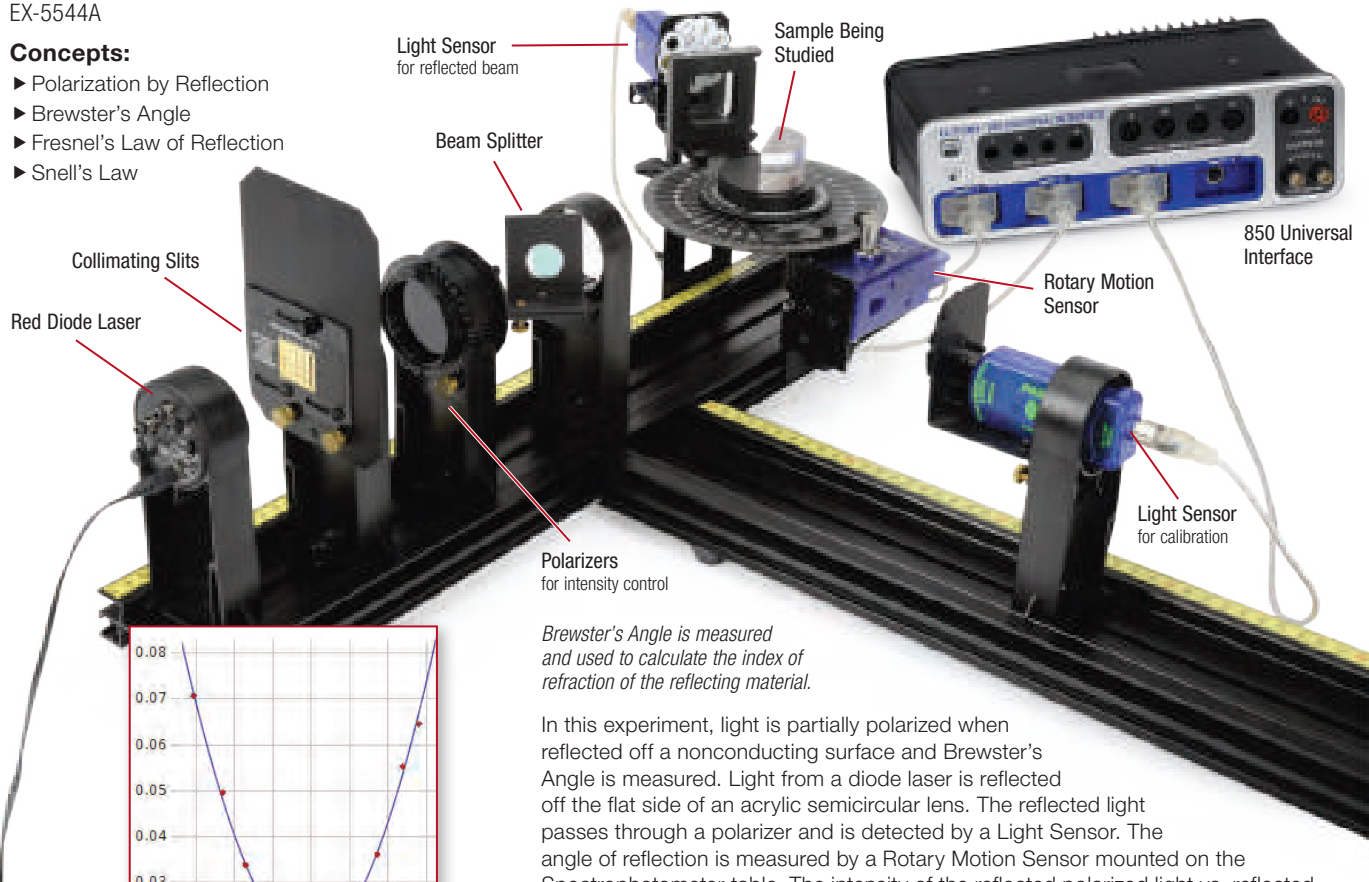
Waves and Optics

Brewster's Angle Experiment

EX-5544A

Concepts:

- Polarization by Reflection
- Brewster's Angle
- Fresnel's Law of Reflection
- Snell's Law



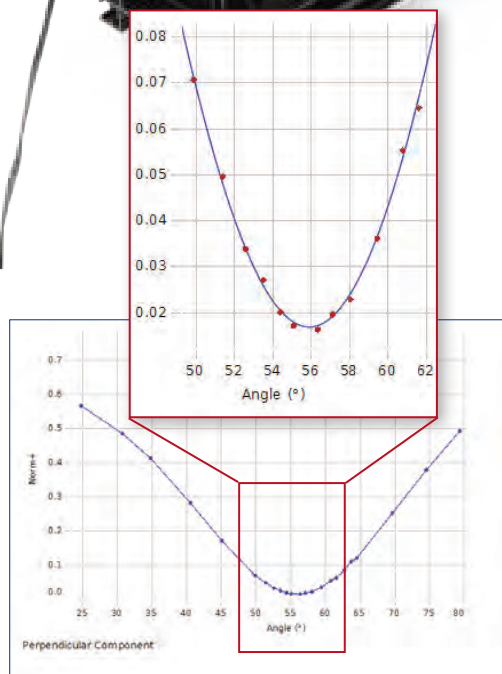
Brewster's Angle is measured and used to calculate the index of refraction of the reflecting material.

In this experiment, light is partially polarized when reflected off a nonconducting surface and Brewster's Angle is measured. Light from a diode laser is reflected off the flat side of an acrylic semicircular lens. The reflected light passes through a polarizer and is detected by a Light Sensor. The angle of reflection is measured by a Rotary Motion Sensor mounted on the Spectrophotometer table. The intensity of the reflected polarized light vs. reflected angle is graphed to determine the angle at which the light intensity is a minimum. This is Brewster's Angle, which is used to calculate the index of refraction of acrylic.

PASCO Advantage:

It is possible to determine the difference in index of refraction for different wavelengths of light. This is accomplished by using a beam-splitter and a second light sensor to compensate for the variation of the laser intensity. The reflected beam intensity is normalized by the intensity of the laser. This modification to the experiment was suggested by Cristian Bahrim and Wei-Tai Hsu in the American Journal of Physics article: "Precise Measurement of the Refractive Indices for Dielectrics Using an Improved Brewster Angle Method", Vol. 77, page 337 (2009).

Developed using original ideas from P.J. Ouseph, Professor of Physics at University of Louisville, KY: "Polarization of Light by Reflection and the Brewster Angle" by P.J. Ouseph, Kevin Driver, and John Conklin, Am. J. Phys. 69, 1166 (2001).



Brewster's Angle is determined by finding the angle at which no light is transmitted through the analyzing polarizer.

Includes:

- Brewster's Angle Accessory OS-8170A
- Educational Spectrophotometer Accessory Kit OS-8537
- Optics Benches (60 cm) (2) OS-8541
- PASPORT Rotary Motion Sensor PS-2120A
- PASPORT High Sensitivity Light Sensor (2) PS-2176
- Aperture Bracket (2) OS-8534A
- Red Diode Laser OS-8525A
- Polarizer Set OS-8473

Download This Experiment

The FREE experiment files include a pdf of the student instructions and a PASCO Capstone™ workbook file. Download this experiment at pasco.com/CapstoneExperiments.

Order Information

Brewster's Angle Experiment EX-5544A

Required:

550 or 850 Universal Interface* pp. 20-23

PASCO Capstone Software pp. 8-11

* This experiment can be performed using the 550 or 850 Universal Interface or any PASPORT interface with two ports.

Speed of Light Experiment

EX-9932A

Concepts:

- Determine the Speed of Light in Air
- Recreate Foucault's Historical Experiment



The Speed of Light Experiment uses laser light and a high speed rotating mirror to determine this fundamental constant using the Foucault method.

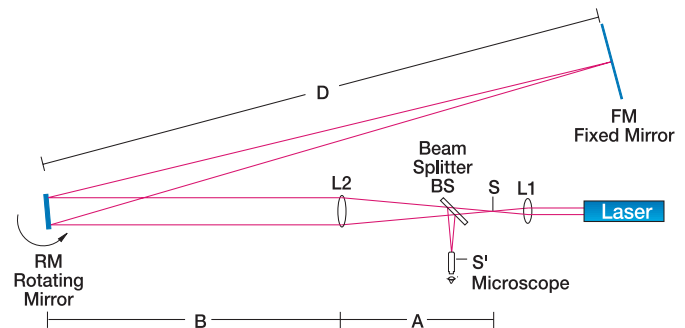
Laser light passes through a series of lenses to produce an image of the light source at a measured position. The light is then directed to a rotating mirror, which reflects the light to a fixed mirror at a known distance from the rotating mirror. The laser light is reflected back through its original path and a new image is formed at a slightly different position. The difference between the final and initial positions, the angular velocity of the rotating mirror, and the distance traveled by the light are then used to calculate the speed of light in air.

PASCO Advantage:

PASCO's Speed of Light Experiment allows students to experimentally measure the speed of light within 5% of the accepted value. In addition, the experiment can be performed on a desktop or in a hallway.

Includes:

- Complete Speed of Light Apparatus OS-9261C
- Speed of Light Experiment Manual



Download This Experiment

Search for EX-9932B at pasco.com

Order Information

Speed of Light Experiment EX-9932A
(No interface required.)

Atomic Spectra Experiment

EX-5546B

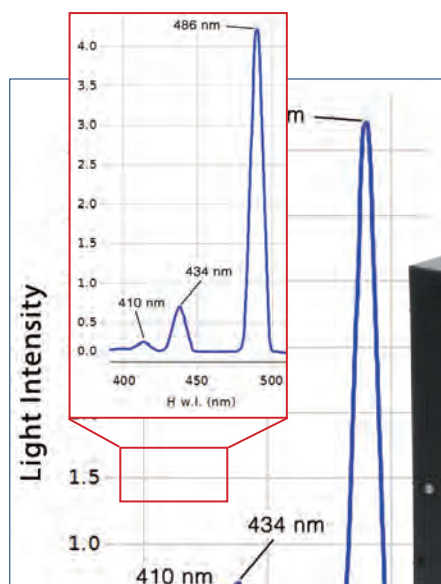
Concepts:

- ▶ Hydrogen balmer series
- ▶ Helium spectrum
- ▶ Mercury doublet

The wavelengths of the discrete lines of the atomic spectra of various gases are measured using a grating spectrophotometer.

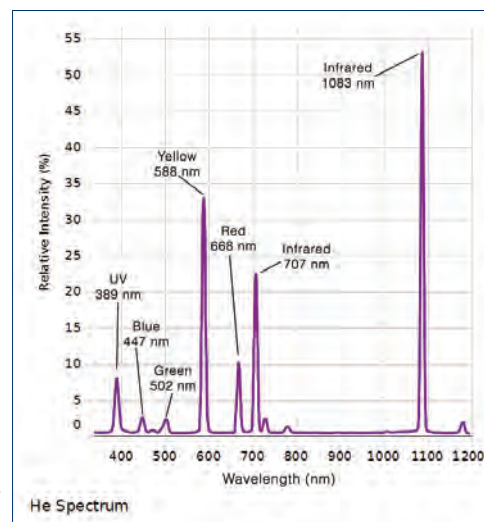
The atomic spectra of hydrogen, helium, and mercury are scanned by hand using a grating spectrophotometer, which measures relative light intensity as a function of angle. From the resulting graph, the wavelengths of the spectral lines are determined by measuring the angle from the central maximum to each line. First and second order lines are examined.

The wavelengths of the spectral lines are compared to the accepted values and, in the case of hydrogen, the electron orbit transitions corresponding to the lines are identified.



The four brightest lines of the Balmer series for hydrogen

The spectral lines of helium are scanned.



PASCO Advantage:

The open construction of the spectrophotometer allows the entire spectrum to be seen, while the intensity vs. angle is graphed in real time.



Includes:

- Educational Spectrophotometer Accessory Kit OS-8537
- Optics Benches (60 cm) OS-8541
- Aperture Bracket OS-8534A
- PASPORT High Sensitivity Light Sensor PS-2176
- PASPORT Rotary Motion Sensor PS-2120A
- Round Base with Rod (2) ME-8270
- Spectral Tube Power Supply and Mount SE-9460
- Spectral Tube (Hydrogen) SE-9461
- Spectral Tube (Helium) SE-9462
- Spectral Tube (Mercury) SE-9466

Download This Experiment

The FREE experiment files include a pdf of the student instructions and a PASCO Capstone™ workbook file. Download this experiment at pasco.com/CapstoneExperiments.

Order Information

Atomic Spectra Experiment..... EX-5546B

Required:

550 or 850 Universal Interface* pp. 20-23

PASCO Capstone Software pp. 8-11

* This experiment can be performed using the 550 or 850 Universal Interface or any PASPORT interface with two ports.

Photoelectric Effect Experiment

EX-5549A

Concepts:

- Connects to the 850 Universal Interface for data collection in PASCO Capstone
- Find Planck's Constant within 5%
- Verify that stopping voltage is independent of intensity
- Find characteristics of the photodiode

The Photoelectric Effect System is used to perform the photoelectric experiment, determining Planck's Constant 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, selected from a mercury lamp using filters. The voltage is then adjusted to stop the photoelectric current. The stopping voltage is plotted vs. the frequency, and Planck's Constant is determined from the slope of the graph. The concept that the stopping voltage does not change with light intensity is tested using the various apertures that change the light intensity by partially blocking the light.

Use the 850 Universal Interface and PASCO Capstone to collect and analyze data.

Both the picoammeter and the power supply for the stopping voltage have sensor ports on the front that connect to the analog sensor ports of the 850 Universal Interface. PASCO Capstone automatically recognizes these instruments and can read the current and the voltage. During the experiment, each time a different filter is applied, the user clicks "Keep" in PASCO Capstone and the value of the stopping voltage for that frequency is recorded and automatically graphed vs. frequency.

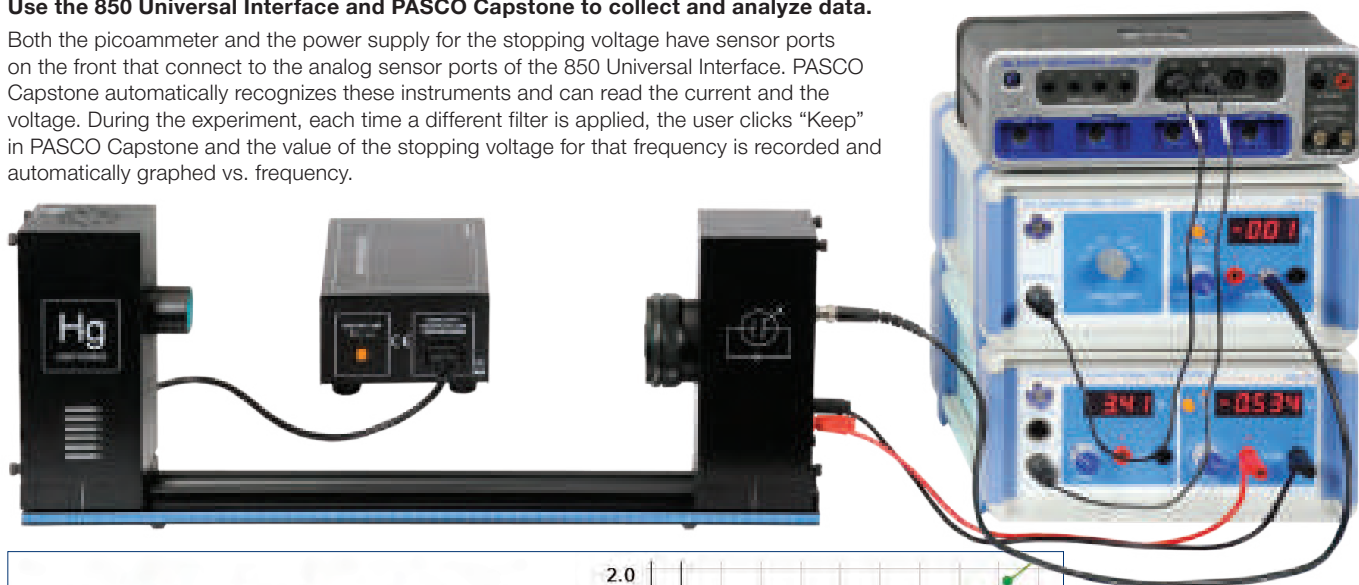
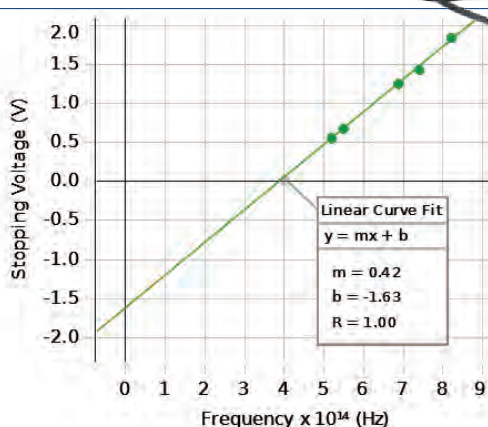


Table I: Photoelectric Effect with 4 mm Aperture

	▲ Run #1	■ Run #1
	Frequency $\times 10^{14}$ (Hz)	Stopping Voltage (V)
1	8.214	1.835
2	7.408	1.428
3	6.879	1.248
4	5.490	0.671
5	5.196	0.551



For the typical sample data shown, the graph of Stopping Voltage vs. Frequency gives a slope of 4.2×10^{-15} V-s. This results in a value for Planck's Constant of 6.7×10^{-34} J-s, which is 1.3% above the accepted value. Graph generated using PASCO Capstone software.

Includes:

- Basic Photoelectric Effect Apparatus SE-6614
- DC Current Amplifier SE-6621
- DC Power Supply I (Constant Voltage) SE-6615
- Cables for 850 Interface

Download This Experiment

The FREE experiment files include a pdf of the student instructions and a PASCO Capstone™ workbook file. Download this experiment at pasco.com/CapstoneExperiments.

Order Information

Photoelectric Effect Experiment EX-5549A

Required:

550 or 850 Universal Interface pp. 20-23

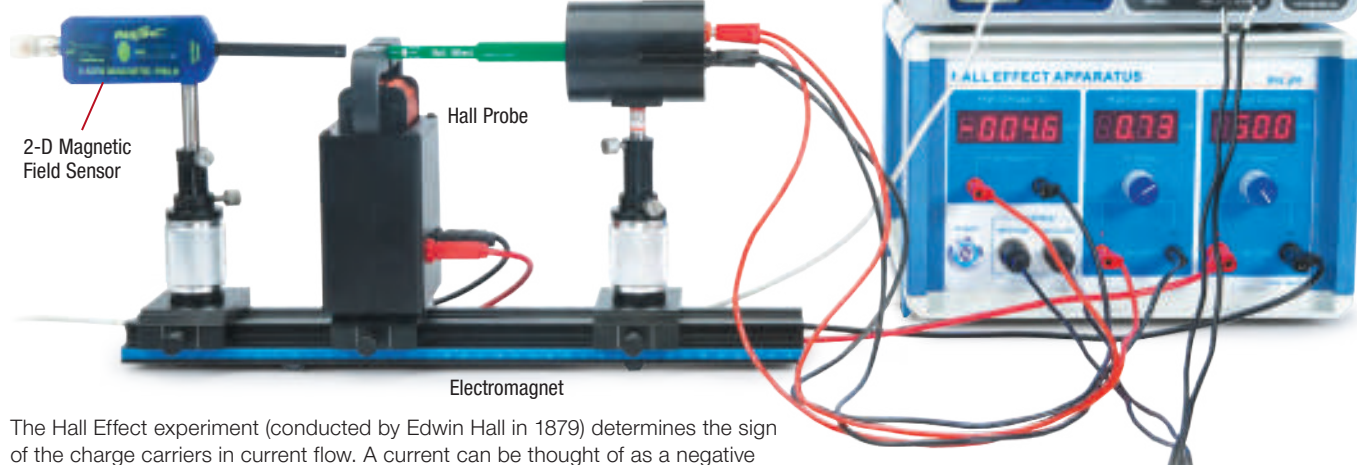
PASCO Capstone Software pp. 8-11

Hall Effect Experiment

EX-5560

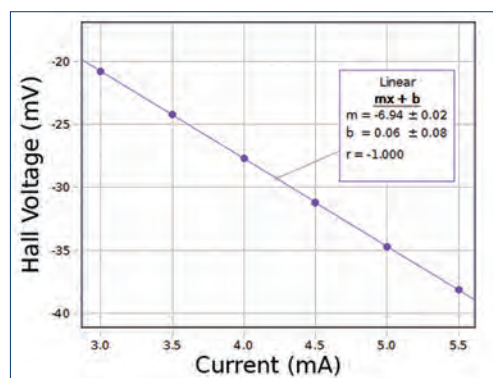
Concepts:

- Determine sign of charge carriers
- Vary magnetic field and current



The Hall Effect experiment (conducted by Edwin Hall in 1879) determines the sign of the charge carriers in current flow. A current can be thought of as a negative charge moving in one direction (Figure 1) or as a positive charge moving in the opposite direction (Figure 2). To determine which it actually is, the semiconductor is immersed in the magnetic field transverse to the direction of the current flow. The moving charge experiences a force, causing a charge buildup on one side of the semiconductor (creating an electric field), which in turn leads to a force. The direction of the electric field will depend on the sign of the charge carriers, which is revealed by the polarity of the Hall voltage across the semiconductor.

The magnitude of the Hall voltage is dependent on the current, the charge carrier density, and the magnitude of the magnetic field. In modern day electronics, the Hall Effect is used to measure the magnitude and direction of magnetic fields.



Using the 550 Universal Interface to record data, this plot of the Hall Voltage vs. the Current was made in PASCO Capstone software. In this case, the magnetic field was held constant and the current through the semiconductor was varied.

Includes:

- Hall Probe Unit, n-Semiconductor (GaAs)
- Hall Effect Power Supply
- U-Core Electromagnetic Coil
- Track, Length 40 cm
- Optical Carrier (2)
- PASPORT 2-Axis Magnetic Field Sensor PS-2162
- Adjustable Post Holder with 9 cm Post (2)
- Banana Cords (6)
- Connecting Cables for 550/850 Interface (2)

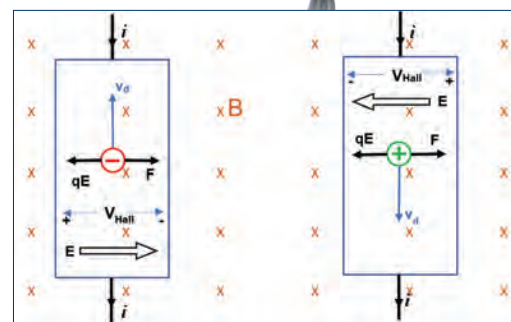


Figure 1

Figure 2

PASCO Advantage:

The open design of this Hall Effect apparatus makes it possible for students to see the direction of the current and the magnetic field, enabling them to use the sign of the Hall voltage to deduce the sign of the charge carriers.



The directions of the current and the voltage probe are clearly marked on the probe that holds the semiconductor.

Download This Experiment

The FREE experiment files include a pdf of the student instructions and a PASCO Capstone™ workbook file. Download this experiment at [pasco.com/CapstoneExperiments](https://www.pasco.com/CapstoneExperiments).

Order Information

Hall Effect Experiment.....EX-5560

Required:

550 or 850 Universal Interface..... pp. 20-23

PASCO Capstone Software..... pp. 8-11

Franck-Hertz Experiment

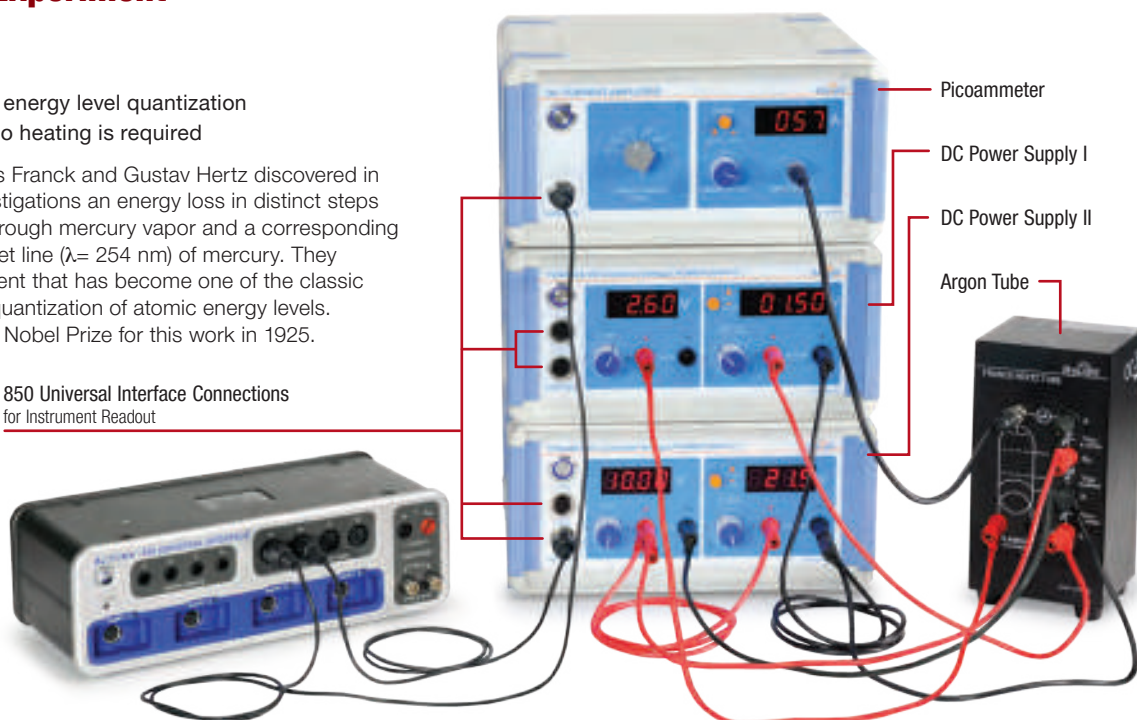
EX-5561

Concepts:

- Demonstrate atomic energy level quantization
- Uses argon gas so no heating is required

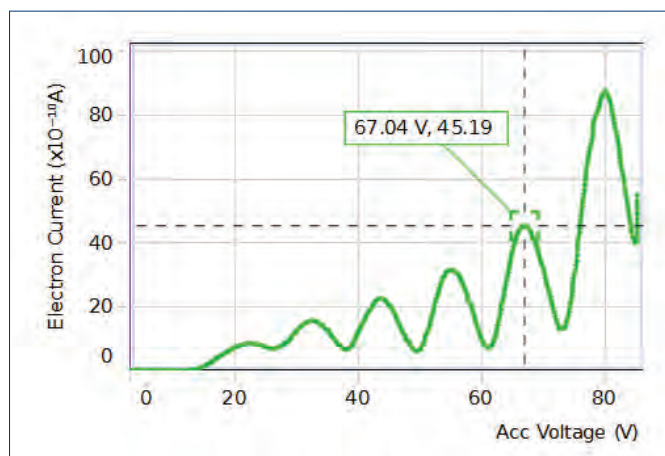
As early as 1914, James Franck and Gustav Hertz discovered in the course of their investigations an energy loss in distinct steps for electrons passing through mercury vapor and a corresponding emission at the ultraviolet line ($\lambda = 254$ nm) of mercury. They performed this experiment that has become one of the classic demonstrations of the quantization of atomic energy levels. They were awarded the Nobel Prize for this work in 1925.

850 Universal Interface Connections
for Instrument Readout



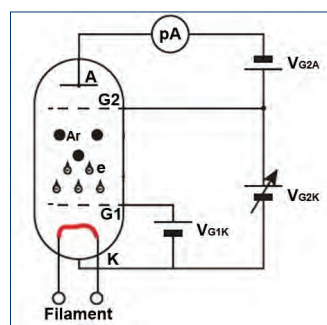
PASCO Advantage:

With PASCO Capstone, students can collect many more data points compared to manually taking readings from the digital readouts. The peaks and troughs are easily measured using the coordinate tool.



Includes:

- Franck-Hertz Tube Enclosure with Argon Tube SE-9650A
- DC Power Supply I (Constant Voltage) SE-6615
- DC Power Supply II (Constant Voltage) SE-9644
- DC Current Amplifier SE-6621
- Red and Black Patch Cords
- Interface Cables (2)



This diagram shows the internal structure of the Franck-Hertz tube and the wiring diagram.

How It Works:

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.

As the accelerating voltage is increased, the electrons undergo multiple collisions and the excitation energy of the argon atom can be determined by the differences between the accelerating voltages that cause a decrease in the current. Planck's Constant can be determined.

Order Information

Franck-Hertz Experiment EX-5561

Required:

550 or 850 Universal Interface pp. 20-23

PASCO Capstone Software pp. 8-11

Download This Experiment

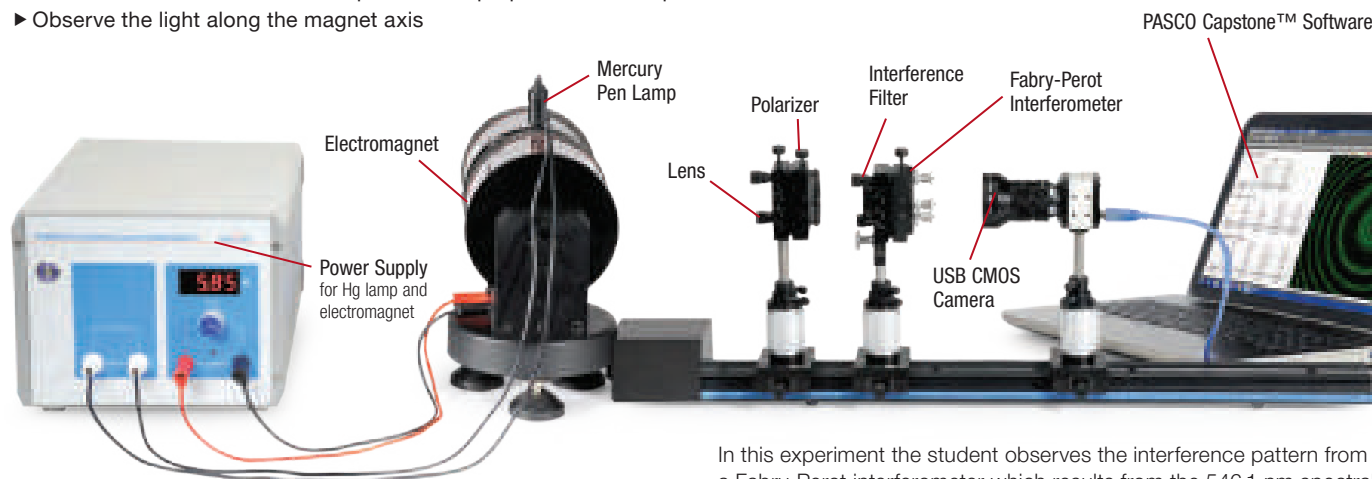
The FREE experiment files include a pdf of the student instructions and a PASCO Capstone™ workbook file. Download this experiment at pasco.com/CapstoneExperiments.

Zeeman Effect Experiment

EX-5562

Concepts:

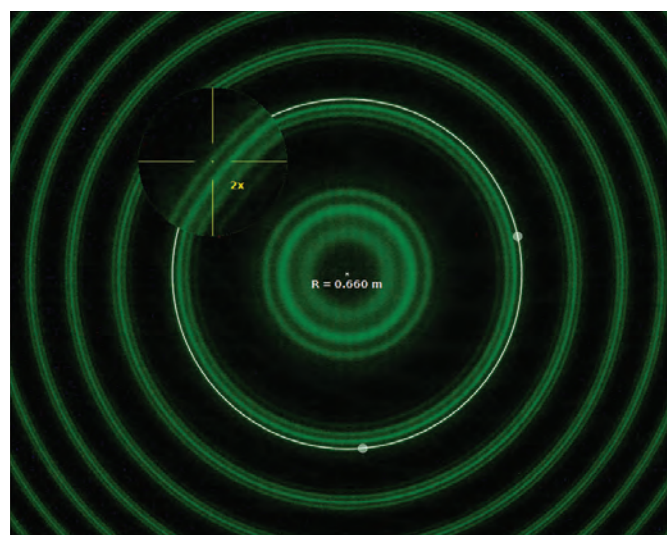
- ▶ Measure the Zeeman Effect with polarization perpendicular and parallel to the field
- ▶ Observe the light along the magnet axis



End view through the axis of the magnet



Electromagnet produces about one Tesla.



In this experiment the student observes the interference pattern from a Fabry-Perot interferometer which results from the 546.1 nm spectral line of a mercury lamp immersed in a uniform magnetic field. The magnetic field is varied from zero to nearly 1 Tesla.

Initially, the light is viewed along an axis perpendicular to the magnetic field axis. A polarizer is used to show the three lines due to light that is polarized parallel to the field axis and to show the six lines that are polarized perpendicular to the field axis. The pattern may also be viewed along the field axis where the light is circularly polarized.

Finally, the pattern that is polarized perpendicular to the field axis is used to calculate the Bohr magneton. All atomic magnetic moments are integral or half-integral multiples of the Bohr magneton.

PASCO Advantage:

In PASCO Capstone software, students can use the video magnifier tool to enlarge the region and observe the line splitting in detail. Also, the radius tool needs only three points to define the circle, so even rings that are partially out of view can be measured.

Includes:

- Electromagnet
- Power Supply
- Optics
- Tesla Meter

Order Information

Zeeman Effect Experiment EX-5562

Required:

PASCO Capstone Software pp. 8-11
(No interface required.)

Download This Experiment

The FREE experiment files include a pdf of the student instructions and a PASCO Capstone™ workbook file. Download this experiment at pasco.com/CapstoneExperiments.

AP-8210B.....	260, 324	EM-6720.....	262	EX-5504A.....	342	ME-1247.....	116	ME-6855.....	146, 209
AP-8211.....	260, 324	EM-6722.....	256	EX-5506.....	343	ME-1248.....	113	ME-6856.....	183
AP-8212.....	260, 324	EM-6723A.....	256	EX-5509B.....	345	ME-1249.....	115	ME-6957.....	120
AP-8213C.....	178	EM-6724.....	256	EX-5510C.....	345	ME-1251.....	113	ME-6960.....	118
AP-8214B.....	178	EM-8099.....	255	EX-5513A.....	348	ME-1252.....	114, 140, 196	ME-6965.....	118
AP-8215B.....	330	EM-8607.....	263	EX-5517C.....	353	ME-1253.....	114	ME-6967.....	118
AP-8218.....	330	EM-8609.....	257	EX-5521A.....	355	ME-1254.....	113	ME-6972.....	183
AP-8219A.....	330	EM-8610.....	257	EX-5522A.....	357	ME-1260.....	194	ME-6974.....	171
AP-8221A.....	178	EM-8611.....	257	EX-5523A.....	356	ME-1261.....	195	ME-6977.....	119
AP-8222.....	179	EM-8612.....	257	EX-5529A.....	364	ME-1262.....	138	ME-6978.....	278
AP-8223.....	179	EM-8613.....	257	EX-5532.....	367	ME-1263.....	143	ME-6983.....	166
AP-8586.....	333	EM-8614.....	257	EX-5533.....	370	ME-1272A.....	117	ME-6984.....	170
CI-6460.....	36	EM-8615.....	257	EX-5534.....	371	ME-1273A.....	117	ME-6985.....	171
CI-6504A.....	30	EM-8618.....	255	EX-5535.....	372	ME-2040.....	78	ME-6986.....	171
CI-6512.....	242	EM-8620.....	266	EX-5536.....	372	ME-2220.....	45, 199	ME-6987.....	171
CI-6520A.....	30	EM-8622.....	245	EX-5537.....	373	ME-2221.....	45	ME-6988A.....	37, 167, 171
CI-6537.....	26	EM-8624A.....	246	EX-5538.....	374	ME-2224A.....	45, 199	ME-6990.....	160
CI-6538.....	26, 186	EM-8627.....	247	EX-5542.....	381	ME-3419.....	35, 194	ME-6991.....	161
CI-6556.....	29	EM-8628.....	247	EX-5543A.....	385	ME-3420.....	35, 194	ME-6992B.....	162-163, 167
CI-6604.....	30	EM-8629.....	249	EX-5544A.....	386	ME-3581.....	159, 170	ME-6993.....	171
CI-6605A.....	28	EM-8630.....	247	EX-5546B.....	388	ME-5300.....	76	ME-6994.....	171
CI-6688A.....	35	EM-8631A.....	267	EX-5547A.....	383	ME-5301.....	77	ME-6995.....	171
CI-6689A.....	197	EM-8632.....	249	EX-5548.....	360	ME-5701A.....	108	ME-6996.....	171
CI-6690.....	185, 189	EM-8634.....	247, 248	EX-5549A.....	389	ME-5702A.....	108	ME-6997.....	171
CI-6692.....	120	EM-8642A.....	255	EX-5550A.....	349	ME-5703A.....	108	ME-6998A.....	171
CI-6693.....	26	EM-8644B.....	254	EX-5551A.....	354	ME-5705A.....	108	ME-6999A.....	171
CI-6742A.....	26	EM-8648B.....	266	EX-5552.....	377	ME-5706A.....	108	ME-7001.....	169
EM-3430.....	241	EM-8652.....	30, 44, 266	EX-5555.....	359	ME-5707B.....	108	ME-7002.....	171
EM-3431.....	241	EM-8654.....	246	EX-5556.....	358	ME-5708B.....	108	ME-7003.....	164-165
EM-3432.....	241	EM-8655.....	249	EX-5560.....	390	ME-5709B.....	108	ME-7008.....	171
EM-3433.....	241	EM-8656.....	244	EX-5561.....	391	ME-5711A.....	108	ME-7009.....	166
EM-3434.....	241	EM-8661.....	259	EX-5562.....	392	ME-5712A.....	108	ME-7011.....	171, 176
EM-3435.....	241	EM-8662.....	259	EX-5563.....	355	ME-5713A.....	108	ME-7012.....	171
EM-3436.....	241	EM-8663.....	245	EX-5564.....	352	ME-5715A.....	108	ME-7017.....	171
EM-3437.....	241	EM-8668.....	244	EX-5565.....	381	ME-5716A.....	108	ME-7018.....	168
EM-3438.....	241	EM-8675.....	245	EX-5566.....	379	ME-5717B.....	108	ME-7019.....	170
EM-3439.....	241	EM-8678A.....	243	EX-5568.....	375	ME-5718B.....	108	ME-7020.....	155
EM-3440.....	241	EM-8679.....	247	EX-5602.....	340	ME-5719B.....	108	ME-7021.....	155
EM-3441.....	241	EM-8784.....	249	EX-5605.....	343	ME-6569.....	120	ME-7022.....	155
EM-3442.....	241	EM-8785.....	249	EX-5611.....	346	ME-6617.....	36	ME-7023.....	156
EM-3443.....	241	EM-8812.....	235	EX-5612.....	348	ME-6622.....	36, 119	ME-7024.....	156
EM-3444.....	241	EM-8813.....	235	EX-5615.....	344	ME-6666.....	33, 123	ME-7025.....	156
EM-3445.....	241	EM-8814.....	247	EX-5616.....	351	ME-6694.....	196	ME-7026.....	157
EM-3446.....	241	EM-8815.....	247	EX-5618.....	353	ME-6743.....	26, 34, 53, 120	ME-7027.....	157
EM-3447.....	241	EM-8817.....	259	EX-5624A.....	361	ME-6755.....	121	ME-7028.....	153
EM-3448.....	241	EM-9099.....	251	EX-5625.....	362	ME-6757A.....	121	ME-7029.....	154
EM-3449.....	241	EM-9740.....	248	EX-5627.....	363	ME-6796.....	138	ME-7030.....	152
EM-3450.....	241	EM-9745.....	248	EX-5630.....	365	ME-6800.....	136	ME-7032.....	102, 208
EM-3451.....	241	EP-3574.....	69, 213	EX-5631.....	366	ME-6802.....	136	ME-7033.....	104, 148
EM-3452.....	241	EP-3575.....	69, 213	EX-5640.....	376	ME-6806.....	133, 213	ME-7034.....	104, 148, 193
EM-3453.....	241	ES-9042A.....	233	EX-5641.....	378	ME-6807A.....	46-47, 150	ME-7035.....	104, 148
EM-3454.....	241	ES-9056.....	233	EX-5645.....	484	ME-6810A.....	27, 33, 139, 141	ME-7037.....	157
EM-3455.....	238	ES-9057C.....	233	EX-9909.....	350	ME-6816.....	200	ME-7038.....	153
EM-3457.....	241	ES-9059C.....	233	EX-9930B.....	368	ME-6821A.....	141	ME-7039.....	154
EM-3458.....	241	ES-9060.....	234	EX-9932A.....	387	ME-6822.....	141, 211	ME-7040.....	152
EM-3533.....	239	ES-9061.....	233	EX-9935.....	347	ME-6824.....	137	ME-7042.....	157
EM-3534.....	60, 237	ES-9070.....	230, 331	EX-9952.....	380	ME-6825B.....	137	ME-7043.....	156
EM-3535.....	236-237	ES-9077.....	233	EX-9987.....	382	ME-6828.....	119	ME-7044.....	102, 208
EM-3536.....	236-237	ES-9078A.....	28, 232	EX-9988.....	383	ME-6829.....	143	ME-7072.....	105
EM-3555.....	240	ES-9079.....	233	ME-1234.....	127, 214	ME-6830.....	142	ME-7073.....	103
EM-3556.....	240	ES-9080B.....	232	ME-1235.....	127, 214	ME-6831.....	142	ME-7074.....	105
EM-3557.....	79	ES-9086.....	231	ME-1240.....	52, 110-111	ME-6837.....	183	ME-7075.....	102
EM-6709.....	257	ET-8499.....	220	ME-1241.....	52, 110-111	ME-6838A.....	27, 149, 203	ME-7076.....	103
EM-6711A.....	256	ET-8771B.....	252	ME-1242.....	113	ME-6841.....	118	ME-7077.....	103
EM-6712.....	256	ET-8772.....	253	ME-1243.....	69	ME-6842.....	180	ME-7078.....	105
EM-6713.....	256	ET-8783.....	253	ME-1244.....	113	ME-6843.....	119	ME-7081.....	103
EM-6714.....	256	EX-5501.....	342	ME-1245.....	114	ME-6844.....	180	ME-7559.....	213
EM-6715.....	256	EX-5503B.....	341	ME-1246.....	116	ME-6853.....	139	ME-7566.....	215

Part Number Index

ME-7589.....	215	ME-8995.....	207	ME-9884.....	36, 120	OS-8910.....	80	PS-3211A.....	60
ME-7590.....	215	ME-8998.....	26, 121	ME-9885A.....	36, 120	OS-9172.....	317	PS-3212.....	60
ME-8088.....	190	ME-8999.....	121, 182	ME-9889.....	134	OS-9255A.....	321	PS-3216.....	159
ME-8094.....	190	ME-9204B.....	27, 126	ME-9890.....	211	OS-9256A.....	321	PS-3219.....	53
ME-8229.....	176	ME-9207B.....	135	ME-9892.....	143	OS-9258B.....	321	PS-3220.....	53
ME-8231.....	174	ME-9215B.....	126	MG-8600.....	268	OS-9261B.....	332	PS-3221.....	64
ME-8232.....	174	ME-9283.....	127	NU-3344.....	65, 336	OS-9263B.....	332	PS-3222.....	59
ME-8233.....	174	ME-9284.....	127	OS-7052.....	105, 307	OS-9477A.....	305	PS-3223.....	55
ME-8234.....	174	ME-9337.....	215	OS-7053.....	307	PI-8117.....	27, 33	PS-3225.....	54, 122
ME-8235.....	174	ME-9350.....	215	OS-7054.....	307	PI-8127.....	274	PS-3227.....	62
ME-8236.....	173, 174	ME-9351.....	215	OS-7055.....	307	PI-9525.....	275	PS-3229.....	56
ME-8237.....	177	ME-9355.....	205	OS-7056.....	307	PK-9023.....	234	PS-3230.....	56
ME-8238.....	177	ME-9376B.....	207	OS-7057.....	307	PK-9025B.....	234	PS-3231.....	68, 85
ME-8239.....	176	ME-9377A.....	33	OS-8170A.....	306	PK-9026.....	234	PS-3232.....	68, 88
ME-8240.....	176, 177	ME-9403A.....	126	OS-8171.....	306	PK-9031B.....	234	PS-3235.....	86
ME-8241.....	176	ME-9426A.....	131	OS-8172.....	305	PS-2103A.....	34, 167	PS-3238.....	65, 336
ME-8242.....	176	ME-9447B.....	145	OS-8439.....	298	PS-2104.....	36	PS-3240.....	62, 231
ME-8243.....	174	ME-9448B.....	121, 149, 203	OS-8440.....	299	PS-2107.....	39	PS-3248.....	63, 318
ME-8244.....	172-173	ME-9450A.....	149, 203	OS-8441.....	299	PS-2115.....	43	PS-3253.....	55
ME-8245.....	177	ME-9471A.....	123	OS-8442.....	299	PS-2120A.....	35, 186	PS-3311.....	68, 85
ME-8246.....	177	ME-9472.....	207	OS-8443.....	316	PS-2125.....	40	PS-3320.....	91, 100-101
ME-8247.....	176	ME-9483.....	149, 203, 205	OS-8450.....	312-313	PS-2131.....	40, 59	PS-3321.....	91, 98
ME-8248.....	176	ME-9495A.....	120	OS-8452.....	300	PS-2134.....	41, 225	PS-3322.....	91, 93
ME-8249.....	177	ME-9498A.....	27, 33, 183	OS-8453.....	302	PS-2135.....	40, 59	PS-3324.....	89
ME-8270.....	204, 205	ME-9499.....	33, 149, 203	OS-8456.....	293	PS-2137.....	151	PS-3325.....	98, 99
ME-8569A.....	202, 219	ME-9502.....	147	OS-8457.....	291	PS-2138.....	151	PS-3326.....	213
ME-8574.....	119	ME-9503.....	147	OS-8458B.....	303	PS-2141.....	37, 151, 167	PS-3327.....	213
ME-8594.....	213	ME-9504.....	147	OS-8459.....	290	PS-2142.....	37, 151	PS-3328.....	213
ME-8734.....	131	ME-9506.....	182, 206	OS-8460.....	294	PS-2143.....	40	PS-3329.....	213
ME-8735.....	204	ME-9507.....	206	OS-8465A.....	291	PS-2146.....	39	PS-3330.....	58
ME-8736.....	204	ME-9509.....	209	OS-8466A.....	293	PS-2150.....	42, 319	PS-3333.....	57
ME-8738.....	204	ME-9510.....	209	OS-8468.....	297, 301	PS-2153.....	40, 59	PS-3335.....	60
ME-8741.....	204	ME-9511.....	209	OS-8469.....	297	PS-2155.....	41, 225	PS-3336.....	60
ME-8743.....	207	ME-9512.....	209	OS-8470.....	291, 308	PS-2158.....	50	PS-3337.....	53
ME-8744.....	207	ME-9513.....	209	OS-8471A.....	290	PS-2159.....	31, 50	PS-3338.....	63
ME-8750.....	119	ME-9595.....	119	OS-8472A.....	290	PS-2160.....	44	PS-3339.....	55
ME-8752.....	182	ME-9774.....	192	OS-8473.....	304	PS-2162.....	44	PS-3342.....	62
ME-8930.....	124-125	ME-9781.....	119	OS-8474.....	292	PS-2176.....	42	PS-3343.....	90
ME-8932.....	125	ME-9803B.....	121, 182	OS-8475.....	333	PS-2180.....	32, 122	PS-3347.....	93
ME-8933.....	33	ME-9804.....	33, 123	OS-8476.....	296	PS-2181.....	39, 45, 199	PS-3349.....	90
ME-8949.....	144	ME-9805.....	27	OS-8477A.....	296	PS-2184.....	29, 43	PS-3351.....	90
ME-8950A.....	186-187	ME-9806.....	120, 123	OS-8479.....	294	PS-2189.....	36	PS-3401.....	217
ME-8951.....	188	ME-9807.....	119	OS-8494.....	293, 297	PS-2197.....	41, 225	PS-3544.....	249
ME-8952.....	188	ME-9812.....	130	OS-8495.....	295	PS-2198.....	38, 159	PS-3599.....	69
ME-8953.....	188	ME-9813.....	130	OS-8496.....	295	PS-2199.....	38, 159, 169	PS-3600B.....	18, 48
ME-8954.....	204	ME-9814.....	130, 171	OS-8501.....	320	PS-2200.....	38, 159	PS-3620.....	18, 49
ME-8955.....	189	ME-9815.....	130	OS-8502.....	320	PS-2201.....	38, 159	PS-3261.....	49
ME-8960.....	184	ME-9819.....	134	OS-8508.....	294	PS-2204.....	38, 167	PS-3703.....	54, 123
ME-8961.....	184	ME-9821.....	191	OS-8510.....	294	PS-2205.....	38, 159	PS-3704.....	54, 149, 203
ME-8963.....	185	ME-9823.....	120	OS-8514.....	317	PS-2206.....	38, 159	PS-4201.....	58
ME-8966A.....	201	ME-9824A.....	147	OS-8515D.....	288-289	PS-2222.....	45, 199	PS-4254.....	61
ME-8968.....	141, 192, 211	ME-9825A.....	179	OS-8516A.....	291, 308	PS-2225.....	45, 200	PS-4256.....	59
ME-8969.....	193	ME-9827.....	181	OS-8519.....	293	PS-2226.....	45	PS-4257.....	57
ME-8970.....	180	ME-9833.....	197	OS-8522.....	292	PS-2500.....	31	PS-5050.....	94-95
ME-8971.....	120	ME-9836.....	119	OS-8524.....	292	PS-2546.....	26, 34, 53	PS-5051.....	95
ME-8972.....	119	ME-9837A.....	191	OS-8525A.....	303	PS-2547.....	151	SA-9241.....	149, 203
ME-8977.....	204	ME-9838.....	132	OS-8526A.....	317	PS-2548.....	37, 151	SA-9242.....	149, 203, 205
ME-8978A.....	205	ME-9847.....	192	OS-8531A.....	301	PS-2600A.....	15, 67, 310	SB-9549A.....	271
ME-8979.....	194, 195, 215	ME-9850.....	133	OS-8533A.....	304	PS-2601.....	310	SB-9631B.....	250, 269
ME-8980.....	215	ME-9859.....	140	OS-8534A.....	303	PS-2611.....	46-47, 150	SB-9632.....	250, 269
ME-8981.....	215	ME-9864.....	141, 211	OS-8535A.....	303	PS-2976.....	89	SE-2952.....	99
ME-8982.....	215	ME-9865.....	141	OS-8537.....	312-313	PS-2978.....	89	SE-2953.....	101
ME-8983.....	215	ME-9866.....	180	OS-8539.....	312-313	PS-2994.....	96, 98, 99, 101	SE-2975.....	89, 99
ME-8984.....	215	ME-9868A.....	141	OS-8541.....	294	PS-2995.....	96	SE-2977.....	89
ME-8985.....	215	ME-9872.....	141, 211	OS-8542.....	314	PS-3200.....	18, 50	SE-3607.....	15, 66, 310
ME-8986.....	120, 129, 210	ME-9873.....	207	OS-8543.....	314	PS-3201.....	58	SE-3608.....	66
ME-8987.....	179	ME-9875.....	210	OS-8544.....	314	PS-3202.....	55	SE-3609.....	66
ME-8989.....	204	ME-9876.....	171, 210	OS-8549.....	304	PS-3203.....	57	SE-3610.....	66

SE-3611.....	66	SE-7726.....	266	SE-9372.....	207	SN-8110.....	337	WA-9406.....	280
SE-6210.....	175, 319	SE-7728.....	287	SE-9373.....	207	SN-8111A.....	337	WA-9495.....	282
SE-6597.....	315	SE-7729.....	315	SE-9409.....	210, 286	SN-9085.....	337	WA-9515.....	81
SE-6608.....	315	SE-7730.....	315	SE-9415A.....	248	SN-9794.....	337	WA-9594.....	283
SE-6609.....	326-327	SE-7732.....	264	SE-9444.....	206	SN-9795.....	337	WA-9605.....	283
SE-6612.....	326	SE-7733.....	265	SE-9445.....	206	SN-9796.....	337	WA-9606.....	283
SE-6614.....	326	SE-7734.....	265	SE-9446.....	206	SN-9797.....	337	WA-9800A.....	322
SE-6615.....	270	SE-7735.....	265	SE-9460.....	316	SP-9268A.....	314	WA-9801.....	322
SE-6621.....	270	SE-7736.....	265	SE-9461.....	316	ST-2997.....	92-93	WA-9802.....	322
SE-6658.....	230	SE-7737.....	265	SE-9462.....	316	ST-2998.....	92-93	WA-9826.....	286
SE-6659.....	285	SE-7738.....	265	SE-9463.....	316	ST-7800.....	87	WA-9855.....	280
SE-6673.....	191	SE-7741.....	265	SE-9464.....	316	ST-7820.....	86	WA-9857A.....	278
SE-6849.....	219	SE-7742.....	265	SE-9465.....	316	ST-7830.....	87	WA-9867.....	279
SE-7123.....	248	SE-7940.....	338	SE-9466.....	316	ST-7840.....	97	WA-9881.....	277
SE-7124.....	269	SE-7943.....	338	SE-9467.....	316	ST-7841.....	97	WA-9896.....	277
SE-7182.....	66	SE-7945.....	338	SE-9468.....	316	TD-8350.....	227	WA-9897.....	277
SE-7201.....	309	SE-8028A.....	119	SE-9584.....	271	TD-8498A.....	221	WA-9898.....	277
SE-7231.....	229	SE-8050.....	120, 210	SE-9586.....	273	TD-8550A.....	224	WA-9899.....	276-277
SE-7232.....	229	SE-8505.....	308	SE-9600.....	284	TD-8551A.....	220	WA-9900.....	282
SE-7233.....	229	SE-8506.....	308	SE-9601.....	284	TD-8553.....	226		
SE-7247.....	230	SE-8509.....	314	SE-9622.....	270, 327	TD-8555.....	226		
SE-7249.....	251	SE-8568A.....	202	SE-9626.....	261, 325, 327	TD-8557C.....	219		
SE-7256.....	26, 34, 53	SE-8587.....	272	SE-9629.....	261, 325, 327	TD-8561.....	218		
SE-7260.....	328	SE-8603.....	267	SE-9639.....	323, 327	TD-8565.....	221		
SE-7283.....	226	SE-8604.....	266	SE-9644.....	270, 327	TD-8570A.....	226		
SE-7285.....	141, 207	SE-8619.....	268	SE-9645A.....	323	TD-8572A.....	223		
SE-7287.....	202, 213	SE-8626.....	249, 251	SE-9650A.....	323, 327	TD-8577.....	221		
SE-7288.....	202, 213	SE-8636A.....	224	SE-9654.....	329	TD-8581A.....	223		
SE-7289.....	202, 213	SE-8645.....	251	SE-9655.....	258	TD-8582.....	220		
SE-7301.....	285	SE-8680.....	267	SE-9656.....	271	TD-8583.....	220		
SE-7302.....	309	SE-8685.....	144	SE-9658.....	329	TD-8595.....	222		
SE-7303.....	224	SE-8688.....	315	SE-9659.....	261, 325, 327	TD-8596A.....	222		
SE-7304.....	181	SE-8689.....	269	SE-9660.....	323	TD-8825A.....	219		
SE-7317.....	218	SE-8690.....	210, 287	SE-9700.....	273	TD-8855.....	227		
SE-7319.....	280	SE-8691.....	228	SE-9711.....	248	TD-8856.....	216		
SE-7331.....	182, 285	SE-8693.....	139, 141, 210	SE-9716C.....	317	TD-8888.....	217		
SE-7335B.....	132	SE-8695.....	202	SE-9750.....	248	UI-5000.....	18, 20		
SE-7337A.....	208	SE-8703A.....	212	SE-9751.....	248	UI-5001.....	18, 23		
SE-7342.....	287	SE-8704A.....	212	SE-9756.....	249	UI-5100.....	29		
SE-7345.....	287	SE-8707.....	212	SE-9758.....	249	UI-5101.....	28		
SE-7347.....	210	SE-8708.....	212	SE-9786A.....	250, 269	UI-5102.....	28		
SE-7355.....	229	SE-8710.....	208	SF-6300.....	129	UI-5110.....	29		
SE-7370.....	201	SE-8712A.....	208	SF-6301.....	129	UI-5119.....	22		
SE-7390.....	267	SE-8723.....	212	SF-6302.....	129	UI-5129.....	22		
SE-7430.....	285	SE-8725.....	212	SF-6303.....	129	UI-5200.....	20		
SE-7560.....	213	SE-8726A.....	212	SF-6304.....	129	UI-5210.....	22, 242		
SE-7571.....	211	SE-8728.....	141, 210	SF-6305.....	129	UI-5218.....	22, 31		
SE-7573.....	309	SE-8729.....	210	SF-6306.....	129	UI-5219.....	270		
SE-7574.....	309	SE-8749.....	181	SF-6307.....	129	UI-5220.....	21		
SE-7579B.....	268	SE-8756B.....	212	SF-6308.....	129	UI-5400.....	8-11, 175		
SE-7581.....	293	SE-8757B.....	212	SF-6309.....	129	UI-5800E.....	70-71		
SE-7585.....	257	SE-8758B.....	212	SF-6311.....	129	UI-5801C.....	70-71		
SE-7586.....	202	SE-8759.....	215	SF-6313.....	129	UI-5802B.....	71		
SE-7591.....	131	SE-8760.....	182, 286	SF-9214.....	128	UI-5803.....	71		
SE-7592A.....	135	SE-8792A.....	269	SF-9216.....	129	UI-5813.....	71, 72		
SE-7593.....	266	SE-8799.....	247	SF-9224.....	129	UI-5820.....	73		
SE-7594.....	201	SE-8805A.....	317	SF-9295.....	129	UI-5821.....	73		
SE-7597.....	217	SE-8806.....	132	SF-9298.....	129	UI-5830B.....	74-75		
SE-7598.....	217	SE-8819.....	315	SN-7900B.....	335	UI-5831.....	74-75		
SE-7700.....	201	SE-8821.....	212	SN-7901B.....	334	WA-7428.....	281		
SE-7718.....	230	SE-8823A.....	212	SN-7907.....	336	WA-7429.....	281		
SE-7719.....	230	SE-8828.....	272	SN-7938.....	337	WA-9314C.....	322		
SE-7720.....	264	SE-9013.....	293	SN-7941.....	337	WA-9315.....	322		
SE-7721.....	264	SE-9021A.....	309	SN-7942.....	337	WA-9316A.....	322		
SE-7722.....	266	SE-9022A.....	309	SN-7949A.....	337	WA-9319A.....	322		
SE-7723.....	267	SE-9084B.....	225	SN-7970A.....	336	WA-9401.....	182, 280		
SE-7724.....	286	SE-9269.....	248	SN-7972A.....	337	WA-9404.....	280		
SE-7725.....	285	SE-9358.....	313	SN-7995A.....	337	WA-9405.....	280		

A–B

1-Axis Force Platform –	
PASPORT	37, 151
Wireless	56
1.2 m Optics Track	294
10-32 Adapter	177
100 N Load Cell	38, 159
120 cm Optics Track	294
18 VDC, 3A Power Supply	272
2-Axis Force Platform –	
PASPORT	37, 151
Wireless	56
2-Axis Magnetic Field Sensor	44
2 Meter Patch Cord	248
200-3200 Turn Transformer Coils	6, 256-257
3-Axis Acceleration Altimeter Sensor	55
3-Axis Gyroscope	184
3-D Magnetic Field Demonstrator	267
3-Finger Clamp	206
3-Point Bending	177
4-Point Bending	177
5 N Load Cell	38, 159
5-year Warranty	408
50 mm Diameter Lens Assortment	293
6-Way Structures Connector	170
8-Pin DIN Extender Cable	22, 31
60 cm Optics Bench	294
550 Physics Manual	75
550 Universal Interface	18-19, 23-25
550 Physics Experiment Bundle	74-75
850 Physics Bundles	70-73
850 Accessories	22
850 Comprehensive Physics System –	
Electromagnetism	71
Experiment Manual	72
Mechanics	70
Optics	71
Thermodynamics	71
Waves	71
850 Expansion Board	21
850 Experiment Manual	72
850 Function Generator BNC Cables	22
850 Replacement Power Supply	20
850 Universal Interface	18-20

– A –

A-base Adapter for Rotary Motion	185, 189
A-base Rod Stand	204
Aberration, Spherical –	
see Aperture Accessory	292
Absolute Pressure Sensor	39
Absolute Pressure/Temperature Sensor –	
PASPORT	39
Wireless with Display (OLED)	4, 57
Absolute Zero Apparatus, Sphere	222
Absorbers, Radiation	337
AC/DC Electronics Lab	
Electronic Components	239-244
AC/DC Electronics Laboratory	244
AC/DC Power Supply	7, 271
AC/DC Smart Power Supply	7, 275
Acceleration Altimeter Sensor, 3-Axis	55
Acceleration – Freefall	126, 134-135
Acceleration Sensor, Wireless Force	55
Accelerometer Springs, Amusement Park	131

Accessory Photogate	27, 126
Acoustic Resonance –	
see Resonance Tube	282
Acoustics, Sound Sensor	28, 62
Actuator, Wave Motion	284
Adapter, Freefall Timer	125, 135
Adapters –	
10-32 Adapter	177
Alligator Clip Adapters	249
Digital Adapter	31, 50
Ohaus Balances USB Adapter	212
ScienceWorkshop-to-PASPORT	50
Adiabatic Compression Fire Syringe	221
Adiabatic Gas Law Apparatus	221
Adjustable Angle Clamp	207
Adjustable End Stops	129
Adjustable Lens	293, 297
Adjustable Lens Holder	292
Advanced Microwave Optics System	322
Advanced Nuclear Spectroscopy System	334
Advanced Physics –	
550 Lab Manual	75
550 Experiment Bundle	74
850 Lab Manual	72
850 Physics System	70-73
Lab Stations	76-81
Software	8-15
Advanced Structures Set	162-163
Air Cannon	201
Air Core Solenoid	257
Air Column, Resonance	283
Air Pressure Demo	201
Air Pressure Sensor	57
Air Source, Cordless	132
Air Supply, Variable Output	129
Air Supply, Hose	129
Air Track and Accessories	128-129
Air Velocity, see Pitot Tube	45
AirLink, Wireless	18, 50
Alligator Clip Adapters	249
Alligator Clip Leads	247-249
Alligator Test Leads, Shrouded	249
Alignment Bench, Laser	317
Alnico Bar Magnets	266
Alpha Sources	337
Altimeter/3-Axis Accelerometer	55
Altitude	55
Aluminum Cart and Tracks	106-109
Aluminum Meter Sticks	208
Aluminum Table Clamp	207
Ammeter, Pico –	
see DC Current Amplifier	270
Ampere's Law Accessory	262
Ampere's Law Experiment	377
Amplifier, DC Current	270
Amplifier, Dual Load Cell	38, 159
Amplifier Set with Load Cell	38, 159
Amusement Park Physics	131
Analog Adapter,	
ScienceWorkshop-to-PASPORT	50
Angle Indicator (Dynamics Track)	120
Angle Sensor –	
see Human Arm	46, 150

Angular Momentum Experiment,	
Conservation of	353
Aperture Accessories (Basic Optics)	292
Aperture Bracket, Light Sensor	303
App, MatchGraph!	14, 34, 53
App, PASCO Capstone	8-11
App, SPARKvue	12-13
App, Spectrometry	15, 311
Archimedes' Principle Experiment	202, 350
Argon Tube, Franck-Hertz	327
Arm Model, PASPORT Human	46-47, 150
Atmospheric Pressure Demonstrator	201
Atmospheric Pressure Sensor	39, 45, 57, 199
Atomic Spectra Experiment	388
Atwood's Machine	149, 203
Atwood's Machine Experiment	342
Avogadro –	
see Mole Set	202

– B –

Balance, Current	7, 263, 375
Balance, Equal Arm	144
Balances, Electronic	212
Ball and Ring	217
Ball Catcher	114, 140, 196
Ball Launchers	136-137
Ball Ramp	5, 102-103
Ball Ramp Components	5, 103
Ball Ramp End Stop	5, 103
Ballistic Cart Accessory, Smart	114
Ballistic Pendulum	142
Ballistic Pendulum Accessory	143
Ballistic Pendulum Experiment	346
Ballistic Pendulum Kit	143
Balls	141, 211, 230
Balls, Gravitational Torsion (Spheres)	330
Balls, Replacement Freefall	211
Banana Plugs, Shrouded and Unshrouded	248
Banana-to-Spade Adapters	249
Bar Magnets	266
Barium-133	337
Base, Large Rod	204
Base, Small "A"	204
Base, Small Round w/ rod	205
Base, Support Rod	205
Basic Bridges	358
Basic Calorimetry Set	219
Basic Digital Multimeter	250, 269
Basic Electricity Lab	245
Basic Optics Spares Kit	294
Basic Optics System	288-294
Basic Optics –	
Beam Splitter	306
Concave/Convex Mirror	291, 309
Color Mixer	295
Diode Lasers	303, 317
Light Source	291, 308
Slit Accessories	299, 302
Storage Box	289
System	288
Viewing Screen	294
Basic Variable Capacitor	233
Battery – see Voltaic Cell	251
Battery Holders	247

- Beads, UV315
 Beakers.....202, 213
 Beam Bending.....177
 Beams, Structures171, 176
 Bearings, Spool (Motorized Structures).....155
 Beginning Optics System.....290
 Bell Jar285
 Bench, Optics294
 Bending Accessory.....177
 Beta Sources.....337
 Bicycle Gyro183
 Bimetallic Strip217
 Biomechanics.....46-47, 150
 Blackbody Radiation Experiment314, 364
 Blockly Coding.....9, 13, 82-101
 Black Thread210
 Blower, Air132
 BNC 850 Function Generator Cables.....22
 Boards –
 850 Expansion21
 Boomophone, Boomwhackers.....285
 Bots –
 see PASCObot91, 96-101
 see Robot Car154
 Bohr Magnetism – see Zeeman Effect.....329, 392
 Bounce/No Bounce Ball Set.....210-211
 Brachistochrone – see Roller Coaster130
 Brackets –
 Collisions (Force)36
 Eye Model297
 Force36
 Gyroscope Mount.....185
 Magnetic, Motion Sensor.....26, 34, 53
 Parallel Spring180
 Photogate.....120, 123
 Rocket Engine Test36
 Structure (Force Platform)37, 171
 Braided Physics String210
 Brake, Smart Cart Friction4, 114
 Brewster's Angle Accessory.....306
 Brewster's Angle Experiment386
 Bridge Deflection –
 see Displacement Sensor.....38, 167
 Bridge Set, Structures161
 Bridge Vibrations Experiment360
 Bridges, Basic.....358
 Bridges, Building Better.....170
 Broad Spectrum Light Sensor42, 319
 Browser-Based Application –
 see SPARKvue Software.....13
 Buggy, Constant Speed –
 see Constant Velocity Car.....119
 Building Better Bridges.....170
 Bulbs, Replacement247
 Bumper Accessory Set36, 120
 Bumper Set, Magnetic.....36, 120
 Bumper, Elastic.....26, 121
 Bundles –
 Comprehensive 850.....70-72
 Lab Stations76-81
 Modular Circuits236-241
 STEM92-101
 Universal 550 Physics.....74-75
 Buoyancy222, 349
 Buoyant Force – see Density Set202, 219
 Buret Clamp206
 – C –
 //code.Node68, 84-86, 98, 100
 //code.Node Multi-pack.....85
 //control.Node.....68, 84, 88
 //control.Node Accessories89-90
 //control.Node Kits –
 Greenhouse Sense & Control Kit.....92-93
 PASCObot Sense & Control Kit97
 Sense & Control Kit.....94-95
 //control.Node Platform (Robot Car)157
 //control.Node Voltage Sensor.....90
 "C" Clamps141, 207
 Cable, 8-pin DIN Sensor Extender.....22, 31
 Cables –
 Fiber Optic (UV-Vis)66
 Fiber Optic (Vis).....67
 PASPORT Sensor Extension.....31
 Phone Jack Extender27, 33
 Cadmium-109.....337
 Calibrated Polarizer304
 Calipers, Digital.....208
 Caliper, Optics297, 301
 Calorimeter Cup.....219
 Calorimeter, Energy Transfer220
 Calorimetry Set.....219
 Camera Microscope, USB.....175
 Can, Overflow202
 Cannon, Air201
 Cans, Radiation.....226
 Capacitance Experiment.....370
 Capacitor Box, Decade269
 Capacitor Circuit (RCL, RLC).....22, 242
 Capacitor, 1 Farad249, 251
 Capacitor, Basic Variable233
 Capacitor, CASTLE Kit246
 Capacitors (Assortment)249
 Capstone Experiment List.....339
 Capstone Software –
 see PASCO Capstone.....8-11, 175
 Carbon Paper139, 141, 210
 Carriage, Dynamics Track Optics.....290
 Cart Adapter Accessory,
 Motion Sensor26, 34, 53
 Cart, GrateNells.....69, 213
 Cart Launcher, Spring.....119
 Carts and Accessories –
 Angle Indicator120
 Ballistic Cart Accessory.....114
 Brake, Friction (Smart Cart)4, 114
 Bumper Accessory Set.....36, 120
 Cart Adapter Accessory.....26, 34, 53, 120
 Cart Damping Accessory, Magnetic36, 120
 Cart Mass (set of 2).....121
 Classic Carts106-109
 Collision Cart.....106-109
 Compact Cart Mass.....121
 Constant Velocity Cart –
 see Constant Velocity Car.....119
 see Smart Fan.....113
 Dynamics Cart Tracks106-109, 119
 Dynamics Track Spring Set.....121
 Elastic Bumper26, 121
 End Stops, Adjustable129
 End Stops, Dynamics Track120
 End Stops, Fixed.....129
 Fan Accessory, Smart113
 Fan Kit (Smart Cart)4, 113
 Fan Cart.....119
 Feet, Adjustable.....119
 Friction Block119
 Friction Brake, Smart Cart4, 114
 Magnetic Bumper Set36, 120
 Mass, Cart121
 Measurement Systems.....122-127
 Mechanical Oscillator/Driver119
 Motion Sensor, PASPORT34
 Motion Sensor, ScienceWorkshop26
 Motion Sensor, Wireless53
 Motorized Cart.....116, 119
 Plunger Cart.....106-109
 Replacement Axles120
 Rod Stand Adapter.....113
 Rubber Cord.....120, 129, 210
 Smart Carts.....52, 110-111,
 Smart Cart Accessories.....112-117
 Smart Cart Demo Kits117
 Spring Cart Launcher.....119
 Spring Set.....121, 180
 Super Pulley with Clamp121, 149, 203
 Timing Options122-127
 Tracks108-109, 118-121
 Track Rod Clamp121
 Wheels, Replacement120
 Carts –
 Collision Cart.....106-109
 Plunger Cart.....106-109
 Smart Cart52, 110-111
 Carts & Tracks106-121, 128
 Cast Beams.....166
 Caster Wheel156
 CASTLE Kit246
 Cell, Voltaic.....251
 Cent-O-Gram Balance.....212
 Centripetal Motion & Force –
 Accessory (Computer Based).....186-187
 Accessory (Rotating Platform).....188
 Accessory, Wireless190
 Apparatus190
 Complete Rotational System.....186-187
 Discover (Hand-Held) Kit191
 Experiments343
 Flying Plane.....191
 Pendulum.....191
 Chair, Rotating183
 Chaos Experiment.....356
 Chaos/Driven Harmonic Accessory.....197
 Charge – see Electrometer28, 232
 Charge, Equipotential and Field Mapper234
 Charge Experiment (Electrostatic).....367
 Charge/Discharge Circuit.....243
 Charge of an Electron Experiment.....369
 Charge Producers and Proof Plane233
 Charge Sensor.....62, 231
 Charge-to-Mass Ratio.....261, 325, 327
 Charging Garage, Smart Cart.....69
 Charging Station, Wireless Sensors.....69

Chladni Plates (Standard and Violin).....	280
Circuit Components.....	248-251
Circuit, Charge/Discharge.....	243
Circuit Laws, Kirchhoff's Rules Experiment.....	374
Circuit, Resistor-Capacitor-Inductor.....	22, 242
Circuit, RLC.....	242
Circuits, Modular.....	236-241
Circuits Generator, Modular.....	6, 238
Circulation Model, Density.....	200
Circular Motion – Centripetal Force.....	190-191
Complete Rotational System.....	186-187
Pendulum.....	191
Motor.....	189
Clamp, Track Rod.....	119
Clamps.....	206-207
Class Sets, Sensors.....	69
Clevis Grip.....	177
Cloud Chamber.....	338
Cobalt.....	337
//code.Node – Device.....	68, 84, 98, 100
Multi-pack.....	85
Coding.....	9, 13, 82-101
Coding Kits – //control.Node Sense & Control Kit.....	94-95
Greenhouse Sense & Control Kit.....	92-93
PASCObot Sense & Control Kit.....	96-101
Coils – Air Core Solenoid.....	257
Detector Coils.....	256
Field Coils.....	256
Helmholtz.....	256
Primary and Secondary.....	6, 257
Transformer Coils.....	6, 256-257
Colliding Spheres.....	224
Color Addition.....	295
Color Filter Set (for Color Mixer).....	295
Color Mixer and Accessory Kit.....	295
Compact Cart Mass.....	121
Compass, Liquid Filled.....	267
Compass, Plotting.....	267
Complete e/m System.....	327
Complete Experiments.....	339-392
Complete Interferometer System.....	321
Complete Roller Coaster.....	130
Complete Rotational System.....	186-187
Complete Wave Motion Demonstrator.....	284
Components, Spectrophotometer.....	312-314
Component Testers.....	250, 269
Comprehensive Physics Systems – 850 Complete.....	70
850 Thermodynamics/Waves.....	71
850 Electricity/Magnetism.....	71
850 Mechanics.....	73
Compression Accessory, Materials.....	176
Compression Igniter.....	221
Computer Interfacing – 550 Universal Interface...18-19, 23-25, 74-75	
850 Universal Interface...18-22, 24-25, 70-74	
AirLink.....	18-19, 50
Nuclear Systems.....	334-335
PASCO Capstone Software.....	8-11, 175, 339
Sensors, Wired.....	26-45
Sensors, Wireless.....	51-69
SPARK LXi2.....	18-19, 48
SPARK LX Air.....	18-19, 49
SPARKvue Software.....	12-13
Computer Software.....	8-15
Concave/Convex Mirror Accessory.....	291, 309
Concave Mirror, Demonstration Size.....	291
Conduction, Thermal.....	216-227
Conductive Ink Pen.....	234
Conductive Paper.....	234
Conductive Shapes.....	233
Conductive Spheres.....	233
Conductivity, Thermal.....	238
Conservation of Angular Momentum Experiment.....	369
Conservation of Energy Experiments.....	363-364
Conservation of Momentum Experiment.....	361
Constant Force Cart.....	104-123
Constant Speed Buggy.....	116
Constant Velocity Cart – see Smart Cart Motor/Fan.....	111
Constant Volume Gas Thermometer – see Absolute Zero Apparatus.....	222
Constants, Measurement of Bohr Magnetron (Zeeman Effect).....	329, 392
Charge of an Electron (Millikan).....	260, 324, 369
Coulomb Constant.....	230, 331, 368
Electron Charge-to-Mass.....	261, 325, 327
Newton's Gravitational Constant.....	196, 355
Permittivity of Free Space.....	230, 331
Planck's Constant.....	326, 389
Speed of Light.....	332-333, 387
Constant Mass Rods.....	192
Construction – see Structures.....	158-171
Container Set, 3.8 Liter Plastic.....	213
//control.Node – Accessories.....	89-90
Device.....	68, 84, 88
Sense & Control Kits.....	82-83, 92-101
Convex Mirror, Demonstration Size.....	291
Convex/Concave Mirror.....	291, 309
Cord, Elastic Wave.....	210, 286
Cord, Rubber.....	120, 129, 210
Cord, Yellow.....	210
Cordless Air Source.....	132
Cords, Patch.....	248
Cores, Solenoid.....	257
Cores, Transformer.....	6, 257
Coulomb's Law Apparatus.....	230, 331
Coulomb's Law Experiment.....	368
Counter, Radiation.....	336
Counterweight, Structures.....	157
Coupled Pendulum Experiment.....	355
Cow Magnet.....	266
Crane, Motorized (Structures).....	152
Crooke's Radiometer.....	226
Cube, Leslie's (Thermal Radiation).....	6, 227
Current Balance.....	7, 263, 375
Current-Carrying Wire Experiment.....	7, 263, 375
Current-Voltage, PASPORT.....	43
Current Probe.....	29, 43
Current Sensor, ScienceWorkshop.....	29
Current Sensor, Wireless Module.....	60, 237
Current Sensor, Wireless.....	51-69
Current-Voltage Sensor, Display (OLED).....	4, 61
Curved PASTrack.....	118
Cuvette Rack.....	66
Cuvettes and Caps, Colorimeter.....	66
Cuvette, Quartz.....	66
Cuvette, UV Semi-Micro Volume.....	66
— D —	
Damped Cart Oscillations Experiment.....	354
Damped Harmonic Motion Experiment.....	357
Damped Pendulum.....	197, 353, 357
Damping Accessory, Cart (Friction Brake)...4,	114
Damping Accessory, Magnetic.....	36, 120
DataLoggers.....	18-19, 48-49
DC Constant Voltage Power Supplies.....	270
DC Current Amplifier.....	270
Decade Capacitance Box.....	269
Decade Resistance Box.....	269
Demo Kits, Smart Cart.....	117
Demonstration Mirrors (Concave/Convex).....	309
Demonstration Spring Set.....	180
Demonstration Wave Spring.....	182, 280, 284
Density Circulation Model.....	200
Density Set.....	202, 219
Desktop Electricity Kit.....	245
Detector Coil.....	256
Diffraction Gratings.....	7, 313, 316
Diffraction, Wireless.....	298-299
Diffusion Cloud Chamber.....	338
Digital Adapter, ScienceWorkshop-to-PASPORT.....	50
Digital Calipers.....	208
Digital Indicator – see Displacement Sensor.....	38, 167
Digital LCR Meter.....	269

Dropper Popper	181
Dual Load Cell Amplifier	38, 159
Dual Pressure Sensor	39, 45, 199
Dynamics Systems –	
Accessories	112-113, 119-123
Carts	108-109
Guide	106-112
Tracks	118
Systems	100-121
Dynamics Track Mount Rotary Motion	120
Dynamics Track Optics Kit	290
Dynamometer, Wireless Hand	4, 55

– E –

Economy CASTLE Kit	246
Economy Resonance Tube	282
Elastic Bumper	26, 121
Elastic Wave Cord	210, 286
Elasticity, Stress-Strain	172-179
Electric and Magnetic Interactions	228-234
Electric Circuits	236-251
Electric Field Mapper	234
Electrical Equivalent of Heat,	
Experiment	362
Electricity Kit, Desktop	245
Electricity Lab, Basic	245
Electricity and Magnetism,	
Physics Lab Station	79
Electricity/Magnetism Kit,	
850 Comprehensive	71
Electromagnet	258
Electromagnet (Motorized Structures)	157
Electromagnetic Ring Launcher	259
Electrometer	28, 232, 245
Electron Charge –	
see Millikan Oil Drop	260, 324, 369
Electron Charge-to-Mass Ratio	261, 325, 327
Electronic Balances & Adapters	212
Electronics Laboratory, AC/DC	244
Electroscope	230
Electrostatic Charge Experiment	367
Electrostatic Plume for Van de Graaff	229
Electrostatic Whirl for Van de Graaff	229
Electrostatics Materials Kit	230
Electrostatics Systems –	
Basic	232
Charge Producers	233
Charge Sensor	62, 231
Conductive Shapes	233
Conductive Spheres	233
Electrometer	28, 232, 245
Electroscope	230
Faraday Ice Pail	233
Field Mappers	234
Materials Kit	230
Proof Planes	233
Replacement Pad Set	233
Van de Graaff	228
Voltage Source	233
Wireless	256
e/m Apparatus	261, 325
e/m Replacement Mirror Scale	325
e/m Tube	261, 325

Emission Spectra –	
Power Supply & Mount	316
Sources	316
Spectrometers	66-67
End Stops, Track	5, 103, 120-121, 129
End Stop, Ball Ramp	5, 103
Energy Conservation	347-348
Energy Conversion –	
see Generators	252-253
see Thermoelectric	224
Energy Systems –	
Hydro Accessory	253
Thermoelectric	224
Wind Turbine	253
Energy Transfer –	
Calorimeter	220
Generator	252
Thermoelectric	224
Wind Turbine	253
Engines, Glass Stirling	224
Entry Optics Systems	288-308
Equal Arm Balance	144
Equal Length Spring Set	180
Equilateral Prism	309
Equipotential and Field Mapper	234
Essential Physics Circuits, Modular	237
Expansion, 850	21
Expansion, Thermal	216
Experiment Manuals –	
Comprehensive 850	72
Universal 550	75
Experiment List	339
Experiments –	
Ampere's Law	377
Archimedes' Principle	350
Atomic Spectra	388
Atwood's Machine	342
Ballistic Pendulum	346
Basic Bridges	358
Blackbody Radiation	364
Brewster's Angle	386
Bridge Vibrations	360
Capacitance	370
Centripetal Force	343
Centripetal Force on a Pendulum	343
Chaos	356
Charge of an Electron	369
Conservation of Angular Momentum	353
Conservation of Energy	347
Conservation of Energy II	348
Conservation of Momentum	345
Coulomb's Law	368
Coupled Pendulum	355
Driven Damped Cart Oscillations	354
Driven Damped Harmonic Oscillator	357
Electrical Equivalent of Heat	362
Electrostatic Charge	367
Faraday's Law of Induction	378
Ferromagnetic Hysteresis	6, 379
Franck-Hertz	391
Hall Effect	390
Heat Engine Cycle	365
Hooke's Law	342
Ideal Gas Law	363
Impulse	345

Interference and Diffraction of Light	384
Kirchhoff's Rules (Circuit Laws)	374
Light Intensity vs. Distance	383
LRC Circuit	373
Magnetic Fields of Coils	376
Magnetic Force on a Wire	375
Materials Stress-Strain (Wireless)	344
Mechanical Waves	380
Newton's Law	341
Ohm's Law	372
Photoelectric Effect (Planck's Constant)	389
Physical Pendulum	353
Polarization of Light	385
Projectile Motion	340
Ratio of Specific Heat	366
RC Circuit	372
Reflection and Refraction	382
Resistivity	371
Rotational Inertia	351
Shaking Tower Experiment	359
Sound of Vibrating Strings	381
Specific Heat	361
Speed of Light	387
Static Equilibrium	352
Telescope/Microscope	383
Torsional Pendulum	355
Universal Gravitational Constant	349
Vibrating Strings	381
Waves	380
Work Energy Theorem	348
Zeeman Effect	392
Extension Cable	22, 31
Eye Model Bracket	297
Eye Model, Human	296

– F –

Fabry-Perot Interferometer	321
Fan Accessory, Smart	4, 113
Fan Cart	119
Fan Kit, Smart Cart	4, 113
Fan Rotation Base	113
Faraday Ice Pail and Shield	233
Faraday's Law of Induction Experiment	378
Fast Response Temp Probe	40, 59
Feet, Track	119
Fence, Cart Picket	33
Fence, Photogate	33
Fence, Picket for Smart Timer	33
Ferromagnetic Hysteresis Experiment	6, 379
Fiber Optic Cable	
UV-Vis	66
Vis	67
Fiber Optic Model	309
Field Coil	256
Field Mapper Kits	234
Filings, Iron	267
Filter Set, Color Mixer	295
Fire Syringe	221
Fixed End Stops (Track)	129
Flashlight, UV	315
Flat Coupon Fixture	177
Flex Rod	205
Flexible I-Beam	171
Flow Sensor, General	45, 199-200
Fluid Flow	45, 199-200

Fluids –	
Atmospheric Pressure Demo	201
Bell Jar	285
Flow Sensor	45, 199-200
Physics Lab Station	78
Pipe Network	198
Pitot Tube	45
Venturi Tube	45, 199-200
Flying Plane	191
Force Acceleration Sensor, Wireless	55
Force Bracket	36
Force Platform –	
Handle Set	37, 151
PASPORT 1-Axis	37, 151, 167
PASPORT 2-Axis	37, 151
Structures Bracket	37, 171
Wireless 1-Axis	56
Wireless 2-Axis	56
Force Sensor –	
Balance Stand	36
Bracket	36
Bumper Accessory Set	36
Handle Set, Force Platform	37, 151
High Resolution	36
Magnetic Bumper Set	36
PASPORT	36
Platform, PASPORT	37, 151
Platform, Wireless	56
Rocket Engine Test Bracket	36
ScienceWorkshop	26
Smart Cart	52, 110-111
Wireless, Acceleration	55
Force Table, Super Pulley	145
Forces on a Human Body –	
see Force Platform	56, 151
Four Scale Meter Stick	208
Four-Point Bending	177
Franck-Hertz –	
Apparatus	323
Argon Tube	327
Enclosure	327
Experiment	391
Freefall	134-141
Freefall Adapter	125, 135
Freefall Balls, Accessory	126, 211
Freefall System, Discover	134
Freefall Timer Adapter	125
Friction Block	119
Friction Brake, Smart Cart	4, 114
Friction, Magnetic –	
see Cart Damping	36
F-Stops –	
see Aperture Accessories	292
Function Generators –	
550 Interface	18, 23-25
850 Interface	18-22, 24-25
PASCO	274
Sine Wave Generator	279
Wide Range	271
Fur, Electrostatics	230

– G –

G-M Counter	336
G-M Probe with Sample Holder	336
Galvanometer Sensor	44

Gamma Sources	337
Gamma, Ratio of Specific Heats	366
Gas Law –	
Adiabatic	221
Experiment	363
Heat Engine	223
Ideal	222, 363
Ratio of Specific Heats	366
Gas Thermometer, Constant Volume	
see Absolute Zero Sphere	222
Gauss –	
see Magnetic Field Sensor	30, 44, 64
see Zero Gauss Chamber	30, 44, 64, 266
Gear Set (Motorized Structures)	155
Geiger Counter –	
Sample Holder	65, 336
Wireless	65, 336
Geiger-Müller –	
Intermediate Nuclear Lab	335
Probe with Sample Holder	336
General Flow Sensor	45, 199-200
with Pitot Tube	45
with Venturi Tube	45, 200
General Purpose Digital Multimeter	250, 269
Generator –	
Energy Transfer	252
Hand Crank	251
Hydro-Electric	253
Modular Circuits	6, 238
Sine Wave	279
Steam	217
Wind Turbine	253
Geometric Lens Set	293
Glass Stirling Engine	224
Glassware	202, 213
Gliders, Air Track	129
Glow String	210, 287
Goniometer Probe	151
Goniometer	151
Graduated Cylinders	202, 213
Graph Matching Software	14, 34, 53
Graphing –	
see PASCO Capstone	8-11, 175, 339
Gratings, Diffraction	313, 316
Gratnells Rolling Cart	69, 213
Gratnells Sensor Storage Trays	69, 213
Gratnells Storage Trays	69, 213
Gravitational Torsion Bands	330
Gravitational Torsion Balance	330
Gravity –	
Cavendish Torsion Balance	330
Experiment	349
Green Diode Laser	303
Green Laser Pointer	317
Greenhouse Sense & Control Kit	92-93
Greenhouse Sensor	93
Gripper Accessory, PASCObot	99
Gripper, Motorized Structures (Robot Car)	156
Ground Glass Lenses	293
Grow Light	93
Guard, Motion Sensor	26, 34, 53
Gyrometer –	
see Hand Dynamometer, Wireless	4, 55
Gyroscope, 3-Axis	184

Gyroscope, Bicycle Wheel	183
Gyroscope, Demonstration	184
Gyroscope Disk and Mass	184
Gyroscope Masses, Bicycle	183
Gyroscope Mounting Bracket	185

– H –

Half-Meter Stick	102, 208
Hall Effect –	
Apparatus and Experiment	390
N-Doped Semiconductor	328
Hand Dynamometer, Wireless	4, 55
Hand-Operated Vacuum Pump	320
Hand-Crank Generator (Mini)	251
Hand-Held Centripetal Force	211
Hand-Held G-M Counter	336
Handle Set, Force Platform	167
Harmonic Springs	121, 182
Heat Engine	223
Heat Engine Accessory	223
Heat Engine Cycle Experiment	365
Heat Engines, Stirling	224
Heat Engine/Gas Law Apparatus	223
Heat Expansion	216
Heat, Mechanical Equivalent of	220
Heater-Stirrer	217
Helmholtz Coils	256
High Precision Diffraction Slits	302
High Quality Gratings	313
High Resolution Force Sensor	36
High Resolution Photogate Tape	33, 123
High Sensitivity Light Sensor	42
High Speed Rotating Mirror	332
High Speed Stepper Motor	89
High Voltage Patch Cord Set	248
High Voltage DC Power Supply	273
High Voltage Van de Graaff	228
Hinge, Motorized Structures	157
Hooke's Law Experiment	342
Hooke's Law Set	181
Hooke's Law Spring Set	181
Hooked Mass Sets	215
Hot Plate	217
Hover Puck	132
Hovercraft	132
Hovercraft Blower	132
Human Applications of Physics	150-151
Human Arm Model	46, 150
Human Back Model	169
Human Eye Model	296
Human Leg Model	163, 169
Human Structures Set	169
Hydraulic and Pneumatic Structures	190
Hydro-Electric Generator	253
Hysteresis, Ferromagnetic	6, 379

– I –

I-Beam, Super-Flex	179
I-Beam Set, Structures Flexible	171
Ice Melting Blocks	218
Ideal Gas Law Apparatus	222
Ideal Gas Law Experiment	363
Ideal Gas Law Syringe	222
Igniter, Compression	221
Impulse Experiment	345

Inclined Plane, PASTrack.....	118
Individual Sources, Gamma	337
Induction –	
Faraday's Law	378
Lenz's Law	268
Magnetic Force Accessory.....	255
Primary and Secondary Coils.....	257
Ring Launcher	259
RLC Circuit.....	242
Wand	255
Inductor-Capacitor –	
Resistor Network	22, 242
Inertia, Rotational Moment of	35, 188
Inertia Wands	192
Interface Comparison Guide	18-19
Interfaces, Computer –	
550 Universal Interface	18-19, 23-25
850 Universal Interface	18-21, 24-25
AirLink	18-19, 50
SPARK LX Air.....	18-19, 49
SPARK LXi2	18-19, 48
Interference and Diffraction of Light	
Experiment	384
Interferometer	320-321
Interferometer Accessory Kit.....	321
Inverse Square Law –	
Geiger Counter	336
Light Intensity vs. Distance Experiment	383
Iron Filings.....	267
Isogenerator Kit (Barium-137m).....	337
Isotope Generator, Radioactive.....	337

– J –

Jack, Extender Cable (phone)	27, 33
Jacks, Lab.....	207
Jars –	
Bell	285
Dissectible Leyden	230
Joule Equivalent of Heat.....	362
Jumping Ring –	
see Ring Launcher.....	259

– K –

K Sensor, Temperature	41
Kilovolt Power Supply	7, 273
Kirchhoff's Rules Experiment (Circuit Laws).....	374
Knife Switches.....	247

– L –

Lab Jacks.....	207
Lab Manuals –	
Comprehensive 850 Physics	72
Universal 550 Physics.....	75
Lab Stations –	
Electricity and Magnetism	79
Fluids.....	78
Mechanics Starter.....	76
Mechanics Extension	77
Optics	80
Waves and Sound.....	81
Lamp, Stefan-Boltzmann	226
Large Rod Stand, Base.....	204
Large Slotted Mass Set	215
Large Structures Set.....	164-165
Large Table Clamp.....	207

Laser –	
Diode, Basic Optics.....	303, 317
Green Diode	303
Helium-Neon	317
Laser Alignment Bench	317
Mini	317
Ray Box	308
Red Diode	303
Speed of Light	333
X-Y Adjustable Laser.....	317
Launchers –	
Projectile.....	136-138
Ring	259
Spring Cart.....	119
Launcher Sights.....	141
Launcher Spares Kits	136-137
LCR Meter, Digital	269
Leads, Patch Cords.....	248-249
Leaf Blower	132
LED Indicator for Coils.....	256
Lens, Adjustable	293, 297
Lens Holder, Adjustable	292
Lens Holder Set.....	292
Lens Replacement Set, Human Eye.....	296
Lens Set –	
Accessory	293
Basic Optics Geometric.....	293
Meter Stick Optics	105, 307
Lenses	293
Lenses, Ground Glass	293
Lenz's Law Demonstration	268
Leslie's Cube (Thermal Radiation).....	6, 227
Level, Spirit	210
Leyden Jar	230
Light Bulbs.....	247
Light Bulb Sockets.....	247
Light Intensity vs. Distance Experiment.....	383
Light Sensors –	
Aperture Bracket	303
Broad Spectrum	42, 319
High Sensitivity	42
Light and Color, Wireless.....	63, 318
PASPORT	42
RGB.....	63, 318-319
ScienceWorkshop	30
UVA & UVB.....	63, 318-319
Wireless.....	63, 318
Light Sources –	
Basic Optics	291, 308
Blackbody Light Source.....	314
Diode Laser.....	303
Lasers.....	303, 317
Mercury Vapor Lamp.....	315
Meter Stick Optics	105, 307
Millikan LED	324
Replacement Lamp, Zeeman Effect	329-330
Ripple Generator	277
Spectral Sources	316
Spectral Tube Power Supply	316
Stefan-Boltzmann Lamp.....	226
UV Flashlight	315
X-Y Adjustable Laser.....	317
Light, Speed of	332-333, 387
Limit Switch & Limit Switch Holder	90

Line Follower Module, PASCObot	91, 100
Linear Motion Accessory	35
Linear Polarizer.....	304
Linear Translator	303
Link, Wireless Temperature.....	59
Liquid-Filled Compass.....	267
Load Cells –	
5 N.....	38, 159
100 N.....	38, 159
Wireless.....	55, 159
Load Cell Amplifiers	38, 159
Load Cell and Amplifier Sets.....	38, 159
Longitudinal Wave Spring	182, 280
Loop-the-Loop.....	131
Low Pressure Sensor –	
see Wireless Pressure.....	57
LRC Circuit Experiment	373
LRC Meter, Digital	250, 269

– M –

MagLev Starter Kit	264
MagLev Outreach Set.....	265
Magnaprobe.....	267
Magnet, Cow	266
Magnet, Variable Gap.....	255
Magnetic Bumper Set	36, 120
Magnetic Compass	267
Magnetic Damping Accessory.....	119
Magnetic Demonstration System	254
Magnetic Dip Needle.....	268
Magnetic Drag Demo – see Lenz's Law	268
Magnetic Field Demonstrator.....	267
Magnetic Field Meter	268
Magnetic Field Sensor –	
2-Axis.....	44
PASPORT	44
ScienceWorkshop	30
Wireless 3-Axis	64
Magnetic Fields of Coils Experiment.....	376
Magnetic Force Accessory.....	255
Magnetic Force on a Wire	
Experiment.....	7, 263, 375
Magnetic Induction Generator –	
see Modular Circuits Generator	6, 238
Magnetic Levitation.....	264
Magnetic Motion Sensor Bracket	26, 34, 53
Magnetic Stirrer	217
Magnets.....	266
Malus' Law of Polarization.....	385
Manganese-54	337
Manuals –	
Comprehensive 850 Physics	72
Universal 550 Physics.....	75
Mass and Hanger Sets.....	212, 215
Mass Balances	212, 215
Mass, Constant Wands.....	192
Mass Set, Gyroscope	184
Mass Set, Ohaus Additional	212
Mass Set, Spherical (balls)	141, 192, 211
Mass Sets	212, 215
Mass, Cart.....	121
MatchGraph! App.....	14, 34, 53

Materials	172-179
Materials Testing –	
10-32 Adapter	177
Apparatus	172-174
Bending Accessory	177
Clevis Grip	177
Comprehensive	172-173
Compression Accessory	176
Flat Coupon Fixture	177
Four-Point Load Anvil	177
Machine	174
Photoelasticity Accessory	176
Shear Accessory	176
Storage Base	176
Structures Beam Fixture	176
Systems	172-179
Tensile Samples	174
Matter Model	179
Maxwell's Equations –	
Ampere's Law	377
Faraday's Law	378
Measuring Tape, Metric	208
Measuring with Sensors Guide	16-17
Mechanical Equivalent of Heat	220
Mechanical Equivalent of Heat Brush	220
Mechanical Equivalent of Heat Cylinder	220
Mechanical Oscillator/Driver	119
Mechanical Waves Experiment	380
Mechanics, Physics Lab Stations	76-77
Mechanics, Meter Stick	5, 103-105
Melting Block, Ice	218
Mercury Light Source	315
Mercury Pen Lamp	329
Metal Resonance Strips	280
Meter Stick, Aluminum	102
Meter Stick, Half-Meter	102
Meter Stick, Four Scale	208
Meter Stick Mechanics Sets	5, 103-105
Meter Stick Rotation Components	5, 105
Meter Stick Rotation Set	5, 105
Meter Stick Optics –	
Complete System	105, 307
Components Holder	105, 307
Lens Set	307
Light Source	307
Viewing Screen	307
Meter Stick Physics –	
Ball Ramp	5, 102-103
Optics Set	307
Pivot	104, 148
Rotation Set	5, 105
Torque Set	104, 148
Torque Mass Hanger Set	104, 148
Meters –	
Analog Meters	28, 232
Digital Multimeters	250, 269
Galvanometer	44
Heavy-Duty Student Meters	250
LRC Digital Meter	269
Magnetic Field	268
Temperature Meter	225, 250, 269
Metric Measuring Tape	208
Metric Spring Scales	209

Michelson Interferometer	320
Micrometer	208
Microphone	28
Microscope/Telescope Experiment	383
Microscope, USB Camera	175
Microwave Optics System –	
Accessory Package	322
Detector Probe	322
Mounting Stand	322
Optics System	322
Receiver	322
Millikan LED Light Source	324
Millikan Oil Drop Apparatus	260, 324, 369
Mineral Oil	324
Mini Cars, Roller Coaster	130-131, 171
Mini Cars, Structures	130
Mini Generator, Hand-Crank (Genecon)	251
Mini Laser	317
Mini Launcher	137
Mini Launcher Ballistic Accessory	143
Mini Launcher Spares Kit	137
Mini MagLev, Enhanced	264
Mini Speaker	283
Mirage	309
Mirror, Concave/Convex	291, 309
Mirror, High Speed Rotating	332
Mirrors, Demonstration	309
Modular Circuits	6, 236-241
Modular Circuits Advanced Expansion Kit	240
Modular Circuits Generator	6, 238
Modular LED Strobe	278
Modulated Laser	317
Mole Set	202
Monkey Hunter Demonstration –	
see Shoot-the-Target	139
Motion Graph Matching	14, 34, 53
Motion Sensor –	
Bracket	26, 34, 53
Cart Adapter	26, 34, 53, 120
Elastic Bumper	26, 121
Guard	26, 34, 53
PASPORT	34
Science Workshop	26
Wireless	53
Motor Drive, Rotational	189
Motor/Generator	238, 251-252
Motorized Cart –	
see Smart Cart Motor	116
Motorized Structures –	
Axle Bearings	156
Caster Wheel	156
Counterweight	157
Electromagnet	157
Gear Set	155
Gripper	156
Hinge	157
Limit Switch & Limit Switch Holder	90
Motor Mounts	155
Motorized Crane Kit	152
Motorized Drawbridge Kit	153
Robot Car Kit	154
Spool and Bearings	155
Structures Counterweight	157

Structures Gripper	156
Structures Hinge	157
Turntable	156
Mount, Dynamics Track	120
Mounts, Motor (Structures)	155
Mounting Bracket, Photogate	141
Mounting Rods	33, 149, 203, 205
Mounting Stand, Microwave	322
Multi-Clamp	206
Multi-Color Cup Set, PASCObot	97, 99
Multimeters, Digital	250, 269

– N –

N-Doped Semiconductor, Hall Effect	328
Neodymium Magnets	266
Network, Pipe	198
Network, RCI	22, 242
New Products	4-7
Newton's Laws Experiment	341
No Bounce Ball Set	211
No Bounce Pad	210
Non-Contact Temperature Sensor	41, 225
Nuclear Sensors –	
Geiger Counter, Wireless	65, 336
G-M Tube	336
Nuclear Spectroscopy, USB	334
Nuclear Systems	334-338

– O –

Oersted's Apparatus	268
Ohaus Balances	212
Ohaus Balance Adapters	212
Ohaus Mass Sets	212
Ohmmeters – see Multimeters	250
Ohm's Law Experiment	372
Oil Drop Apparatus, Millikan	260, 324, 369
Oil, Mineral Replacement	324
OLED Display Sensors, Wireless –	
Absolute Pressure-Temperature	4, 57
Temperature	58
Thermocouple	4, 59, 225
Voltage-Current	4, 61
Open Speaker	282
Optical Fiber Model	309
Optics Bench	294
Optics Bench Rod Clamp	294
Optics Caliper	297, 301
Optics Carriage, Dynamics Track	290
Optics, Eye	296-297
Optics Kit, Diffraction	301
Optics Kit, Dynamics Track	290
Optics Kit, Ray	291, 308
Optics, Microwave	322
Optics, Physics Lab Station	80
Optics Systems –	
Basic	288-289
Beginning	290
Diffraction, Sensor-Based	300
Dynamics Track Optics Kit	290
Meter Stick	307
Microwave	322
Optics, Ray Table	291
Oscillations, Driven Damped	354, 357
Oscillator/Mechanical Driver	280
Overflow Can	202

- P -

Paper, Conductive	234	Pendulum Set	182	Polonium-210	337
Parallel Spring Bracket	180	Photogate Head	27, 33	Popper, Dropper	181
Paramagnetism –		Photogate Port (Digital Adapter)	31, 50	Power Output Module	89
see Magnetic Force on a Wire		Photogate Stand	27	Power Supplies, AC and DC –	
Experiment	375	Picket Fence, Cart	33	18 VDC, 3A	272
Partial Immersion Thermometer	225	Picket Fence, Smart Timer	33	AC/DC	7, 271
PASCObot –		Pulley System	27, 149, 203	AC/DC, Smart	7, 275
Bot	96	Smart Gate Pulley, Wireless	54, 149, 203	DC Current Amplifier	270
Gripper	99	Smart Timer	124-125	DC I (Constant Voltage)	270
Line Follower Module	91, 100-101	Smart Timer Photogate System	125	DC II (Constant Voltage)	270, 327
Sense & Control Kit	97	Smart Timer Picket Fence	33	Function Generators	22, 271-275
Range Finder Module	98	Timers	124-127	High Voltage DC	273
PASCO Capstone Software	8-11, 175	Physical Pendulum Experiment	353	Kilovolt	7, 273
PASCO Capstone Experiments	339-392	Physical Pendulum Set	197	Spectral Tube and Mount	316
PASCO Portal	2-3	Physics Lab Manuals –		Triple-Output	272
PASCO Stopwatch	127, 214	Comprehensive 850 Physics	72	Tunable DC	271
PASPORT Interfaces	18-20, 23-25	Universal 550 Physics	75	Precision Interferometer	320-321
PAStrack	108-109, 118	Physics Lab Stations –		Predictions, Capstone Software	8-11
PAStrack, Curved	118	Electricity and Magnetism	79	Pressure Demonstrator, Atmospheric	201
PAStrack Dynamics Systems	119-123	Fluids	78	Precision Digital Multimeter	250, 269
Patch Cords –		Mechanics Extension	77	Pressure Sensors –	
2-meter	248	Mechanics Starter	76	Absolute, PASPORT	39
High Voltage	248	Optics	80	Absolute Pressure-Temp, PASPORT	39
Long	248	Waves and Sound	81	Absolute Pressure-Temp, Wireless	4, 57
Short	248	Physics String	120, 210	Barometer/Low Pressure –	
Shrouded	248	Physiology Sensors –		see Wireless Pressure	57
Pb-210 Cloud Chamber Source	338	Goniometer Sensor	151	Dual, PASPORT	39, 45, 199-200
Pen, Conductive Ink	234	Human Arm Model	46-47, 150	General Flow Sensor, PASPORT ...	45, 199-200
Pendulum –		Pi Set, Discover	133, 213	Low Pressure, Gauge –	
Accessory (Rotary Motion)	193	Picket Fence, Cart	33	see Wireless Pressure	62
Ballistic	142	Picket Fence, Smart Timer	33	Pressure Taps	45, 199
Ballistic, Accessory	143	Picoammeter – see DC Current Amplifier	270	Wireless	62
Ballistic, Experiment	346	Pipe Network	198	Pressure Taps	51, 219
Ballistic, Kit	143	Pith Balls	230	Pressure/Temperature Sensors	4, 39, 57
Ballistic, Mini Launcher	137	Pitot Tube	45	Pressure, Water –	
Centripetal Force	191, 343	Pivot	104, 148, 193	see General Flow Sensor	45, 199-200
Clamp	182, 206	Planck's Constant –		Primary and Secondary Coils	6, 257
Coupled	355	see Photoelectric Effect	326-327, 389	Prism Spectrophotometer	314
Damped	197, 353, 357	Plane, Flying	191	Prisms	309
Physical	197, 353	Plane, Inclined	118	Professional Development –	
Pivot	193	Plastic Balls	141, 211	see PASCO Portal	2-3
Set, Photogate Pendulum	182	Plastic Storage Bins, Grattells	69, 213	Programmable Cart Fan	113
Torsional	196, 355	Plastic Tracks	107-109, 118	Progressive Web Application (PWA) –	
PhiTOP	201	Platform, Chair	183	see SPARKvue Software	13
Photoelasticity Accessory	176	Platform, Force –		Projectile Launchers and Accessories –	
Photoelectric Effect Experiment	389	PASPORT, 1-Axis	37, 151, 167	Ball Catcher	114, 140, 196
Photoelectric Effect System	326-327	PASPORT, 2-Axis	37, 151	Ball Ramp	5, 102-103
Photoelectric Effect,		Wireless, 1- and 2-Axis	56	Ballistic Pendulum	142-143, 346
Tube with Box Plate	327	Platform, Rotating	183, 188	Balls, Replacement	141, 211
Photogate Port –		Plotting Compass	267	Carbon Paper	139, 141, 210
see Digital Adapter	31, 50	Plumb Bobs	141, 210	Drop Shoot	140
Photogate, Smart Gate	32, 122	Plumb Bobs, Projectile Launcher	141	Launcher	136-138
Photogate, Wireless Smart Gate	54, 122	Plume, Van de Graaff	228	Mini Launcher	137
Photogate and Pulley System	27, 149, 203	Plunger Cart	106-109	Photogate Mounting Bracket	141
Photogate Timer	126	Pneumatic Structures	170	Plumb Bobs	141, 210
Photogates and Accessories –		Pointer, Laser	317	Shoot-the-Target Accessory	139
Accessory Photogate	27	Polarimetry Demonstration	305	Sights	141
Brackets	120, 123	Polarization Analyzer	304	Smart Gate System	54, 123
Dynamics System	54, 123	Polarization Experiment	385	Spares Kits	136-137
Fences	33, 123	Polarizer, Calibrated	304	Spherical Mass Set	141, 192, 211
Flags	129	Polarizer Demonstration	305	Time-of-Flight Accessory	27, 33, 139, 141
High Res. Photogate Tape	33, 123	Polarizer Demonstrator Accessory	305	Wireless Smart Gate System	54, 123
Mounting Bracket	141	Polarizer, Linear	304		
Mounting Rods	149, 203, 205	Polarizer Set, Basic Optics	304		

Projectile Motion –	
Ballistic Cart	114
Kit	138
Projectile Launchers	136-141
Projectile Motion Experiment	340
Proof Plane and Charge Producers	233
Protractor, Tension	146, 209
Proximity Sensor –	
see Motion Sensor, Wireless	53
Pulleys and Accessories –	
Demonstration System	144
Mounting Rods (10 pack)	149, 203, 205
Photogate & Pulley System	27, 149, 203
Super Pulley	149, 203
Super Pulley with Clamp	121, 149, 203
Super Pulley w. Mounting Rod	33, 149, 203
Wireless Smart Pulley	54, 149, 203
Pump, Vacuum	320
Pumping Systems	198-199

– Q –

Quad Temperature Sensor, PASPORT	40
Quantitative Spectroscopy	315
Quantum Physics Experiments	388-392
Quartz Cuvettes	66

– R –

Radiation Absorbers	337
Radiation Cans	226
Radiation Counters	336
Radiation Cube, Thermal –	
see Leslie's Cube	6, 227
Radiation Detector (Sensor)	336
Radiation Sensor, Computer Nuclear	334-335
Radiation Sensor, Thermal	226-227
Radiation, Thermal	226-227
Radioactive Cow –	
see Isogenerator	337
Radioactive Source, Cloud Chamber	338
Radioactive Sources	337
Radiometer, Crooke's	226
Ramp, Ball	5, 102-103
Range Finder Module	91, 98
Ratio of Specific Heats Experiment	366
Ray Optics Kit	291, 308
Ray Optics Laser System	308
Ray Table	291
RC Circuit	242-246
RC Circuit Experiment	372
Receiver, Microwave	322
Red Diode Laser	303, 317
Red Laser Pointer	317
Reflection and Refraction	308-309
Reflection, Total Internal –	
see Optical Fiber Model	309
Refraction and Reflection Experiment	382
Relative Pressure Sensor	57
Replacement Axles, Cart	120
Replacement Belt, Van de Graaff	229
Replacement Components, AC/DC Lab	244
Replacement Cuvettes	66
Replacement Parts, Air Track	129
Replacement Parts, Heat Engine	223
Replacement Set, Ripple Tank	277
Replacement Spheres (Gravitational)	330

Replacement Wheel/Axle Set	120
Replacement Wires, Resistance Apparatus	235
Reservoir, Water	213
Resistance Box, Decade	269
Resistivity Apparatus	235
Resistivity Experiment	371
Resistor Assortment	249
Resistor Capacitor Inductor Network	22, 242
Resonance Air Column	
with or without Speaker	283
Resonance Box Set	287
Resonance Strips, Metal	280
Resonance Structures System	168, 359
Resonance Tube, Economy	282
Resonance Wire Loop	280
Right Angle Clamp	206
Right Angle Prism	310
Ring and Ball	217
Ring Launcher	259
Ring Launcher Accessories	259
Ripple Generator/Light Source	276-277
Ripple Tank System	276-277
Ring and Disk Set	194
RLC Circuit	242
Robots –	
PASCObot	91, 96-101
Robot Car	154
Rocket Engine Test Bracket	36
Rocket, Doppler	286
Rod Clamp –	
Double Rod Clamp	207
Optics Bench	294
Structures	171
Dynamics Track	119
Rod Stand, Large	204
Rod Stand Adapter, Smart Cart	113
Rod, Flex	205
Rod, Pulley Mounting	149, 203, 205
Rods, Singing	285
Rods, Stainless Steel	204
Roller Coaster	130
Roller Coaster, Loop-the-Loop	131
Rotary Motion Sensors –	
PASPORT	35
ScienceWorkshop	26
Wireless	53
Rotary Motion Sensor Accessories –	
A-base Adapter	185, 189
Ballistic Pendulum Accessory	143
Centripetal Force Pendulum	191
Chaos/Driven Harmonic Accessory	297
Dynamics Track Mount	120
Gyroscope	185
Gyroscope Mounting Bracket	185
Heat Engine	223
Linear Accessory Kit	35
Linear Translator	303
Pendulum Accessory	143, 193
Polarization Analyzer	304
Rotational Inertia Accessory	35, 188, 194
Spectrophotometer	312-314
Rotating Chair	183
Rotating Platform	188
Rotation, Meter Stick Set & Components	5, 105

Rotational Adapter, A-base	185
Rotational Inertia Accessory	35, 188, 194
Rotational Inertia Experiment	351
Rotational Inertia Set	192
Rotational Inertia Wands	192
Rotational Motion and Torque Kit	195
Rotational Motion Kit	194
Rotational Motor Drive	189
Rotational System, Complete	186-187
Rubber Cord	120, 129, 210

– S –

Scaler/Timer, G-M System	336
Scales, Electronic	212
Scales, Spring	209
ScienceWorkshop	
Cable, 8-pin DIN Extender	22, 31
Screen, Basic Optics	294
Secondary Coils	6, 257
Sense and Control	82-101
Sense and Control Kits –	
Accessories	89
//control.Node	94-95
Greenhouse	91-92
PASCObot	96-101
Motorized Crane	152
Motorized Drawbridge	153
Robot Car	154
Sensor-Based Diffraction System	300
Sensor Extension Cable, PASPORT	31
Sensor Options Overview	16-17, 23-25
Series/Parallel Battery Holder	247
Series/Parallel Spring Set	180
Servo, Continuous Rotation	89
Servo Motor	89
Shaking Tower	168
Shaking Tower, Experiment	359
Shapes, Conductive	233
Shear Accessory, Materials	176
Shoot-the-Target Accessory	139
Shrouded Alligator Clips	248-249
Shrouded Alligator Test Leads	249
Shrouded Cables	22, 248
Sights, Projectile Launchers	141
Signal (Function) Generators	271-275
Sine Wave Generator	279
Singing Rods	285
Single Section Wave Motion	284
Skin/Surface Temp Sensor	40
Slinky, Double Length	182, 286
Slit Set, Basic Optics	299, 302
Slotted Mass Sets and Hangers	212-215
Small "A" Base	204
Small Round Base with Rod	204
Smart Ballistic Cart Accessory	114
Smart Cart Charging Garage	69
Smart Cart Demo Kits	117
Smart Cart Dynamics Systems	106-109, 117
Smart Cart Fan Kit	4, 113
Smart Cart Friction Brake	4, 114
Smart Cart Motor	116
Smart Cart Rod Stand Adapter	113
Smart Cart Trigger Dropper	115

Smart Cart Vector Display.....	116	Spectrophotometer –		Stepper Motor, High Speed.....	89
Smart Carts, Wireless.....	52, 106-111	Accessory Kit.....	312	Stepper Motor, Low Speed.....	89
Smart Fan Accessory.....	113	Educational.....	312-313	Stirling Engine.....	224
Smart Gate, Photogate.....	32, 122	Prism.....	314	Stirrer, Heater.....	217
Smart Gate Projectile System, Wireless.....	138	Rotary Motion.....	313	Stool, Rotating.....	183
Smart Gate, Wireless.....	34, 58, 122-123	Spectroscopes.....	315	Stopwatch 10-Pack, PASCO.....	127, 214
Smart Pulley –		Speed, Constant –		Storage Bins, Plastic.....	69, 213
Super Pulley.....	149, 203	see Constant Velocity Car.....	119	Storage Trays, Grattells.....	69, 213
Wireless.....	54, 149, 203	Speed of Light Apparatus.....	332	Storage Trays, Sensor.....	69, 213
Smart Timer.....	33, 124-125	Speed of Light Experiment.....	387	Strain Gauge – see Force Sensor.....	55
Smart Timer Photogate System.....	125	Speed of Light System, Laser.....	333	Stress-Strain Apparatus.....	178
Snakey.....	182, 285	Speed of Sound (Resonance).....	282	Stress-Strain Test Coupons.....	179
Sockets, Light Bulb.....	247	Sphere, Discharge.....	229	Stress-Strain Wireless Experiment.....	344
Sodium-22 Source.....	337	Spheres, Colliding.....	224	String Vibrator.....	278
Software –		Spheres, Conductive.....	233	String Adapter.....	120
MatchGraph! App.....	14, 34, 53	Spherical Aberration–		String, Braided.....	120, 210
PASCO Capstone.....	8-11, 175, 339	see Aperture Accessories.....	292	String, Glow.....	210, 287
SPARKvue.....	12-13	Spherical Mass Set (Balls).....	141, 192, 211	Strobe.....	278
Spectrometry.....	15, 311	Spirit Levels.....	210	Strontium-90.....	337
Solenoid, Air Core.....	257	Spool and Bearings (Structures).....	155	Structural Strength, Beam Stiffness –	
Sonic Ranger – see Motion Sensor.....	53	Spring Bracket, Parallel.....	180	Structures Beam Fixture.....	176
Sonometer.....	281	Spring Cart Launcher.....	119	Structures Systems and Accessories –	
Sound Level Sensor.....	28, 62	Springs –		#6 I-Beam.....	171
Sound Pipe.....	286	Accelerometer.....	131	6-Way Structures Connector.....	170
Sound Sensor.....	28, 62	Demonstration Set.....	180	Advanced Set.....	162-163
Sources, Radioactive.....	337	Demonstration Wave.....	182, 280	Beams.....	171
Spares –		Dynamics Track.....	119-120	Bracket, Force Platform.....	37, 167, 171
Axles, Cart.....	120	Equal Length.....	180	Bridge Set.....	161
Basic Optics.....	294	Harmonic.....	121	Building Better Bridges.....	170
Capacitor Assortment.....	249	Hooke's Law.....	181	Cast Beams.....	166
Cast Beams.....	166	Longitudinal Wave.....	182, 280	Connectors.....	170-171
Connector.....	171	Series/Parallel.....	180	Cord Lock Spares.....	171
Cord Lock.....	171	Spring Scale –		Displacement Sensor.....	38, 167
Dynamics System Kit.....	120	see Tension Protractor.....	146, 209	Flexible I-Beam Set.....	171
I-Beams.....	171	Spring Scales.....	209	Force Platform Bracket.....	37, 167, 171
Launchers.....	136	Stackable Plastic Bins.....	69, 213	Hydraulic and Pneumatic.....	170
Mass and Hanger.....	215	Stainless Steel Rods.....	204	Large Set.....	164-165
Mini Car Track Spares.....	171	Stainless Steel Temp Probe.....	40	Load Cells & Amplifiers.....	159
Resistor Assortment.....	249	Stainless Steel Temp Sensor.....	58	Mini Car Set.....	130
Roller Coaster.....	130	Stands, Rod.....	204-205	Resonance.....	168, 359
Statics.....	147	Stand-Alone Timers.....	124-125	Roadbed Spares.....	171
SPARK LX Air.....	18-19, 49	Starter Aluminum Tracks.....	106-109	Rod Clamps.....	171
SPARK LXi2 Datalogger.....	18-19, 48	Starter System, 850 Comprehensive –		Roller Coaster Track.....	130
SPARKvue Software.....	12-13	Electromagnetism.....	71	Shaking.....	168, 359
Speaker, Open.....	282	Physics.....	70	Structures Sets.....	158-171
Speaker, Resonance Air Column.....	283	Mechanics.....	70	Track Spares.....	171
Specific Gravity – see Density.....	202, 219	Waves, Optics, Thermodynamics.....	71	Truss Set.....	160
Specific Heats of Gases, Ratio of.....	366	Static Equilibrium –		Truss Set Members.....	171
Specific Heat Set.....	219	Experiment.....	352	Truss Set Screws.....	171
Spectral Lamps.....	316	Statics System.....	147	Vibrations.....	167-168
Spectral Light Sources.....	316	Tension Protractor.....	146, 209	Structures, Motorized –	
Spectral Tubes, Power Supply.....	316	Statics System.....	147	Axle Bearings.....	156
Spectrometer –		Steam Generator.....	217	Caster Wheel.....	156
Cuvettes.....	66	Steel Balls.....	141, 211	Electromagnet.....	157
Educational.....	312-313	Steel Rods.....	204	Gear Set.....	155
Nuclear Spectroscopy.....	334-335	Stefan-Boltzmann Lamp.....	226	Motor Mounts.....	155
Prism Spectrophotometer.....	314	STEM Sense –		Motorized Crane Kit.....	152
Student.....	314	Accessories.....	89	Motorized Drawbridge Kit.....	153
UV-Vis.....	15, 66, 310	//control.Node Sense & Control Kit.....	94-95	Robot Car.....	154
UV-Vis Accessories.....	66	Greenhouse Sense & Control Kit.....	92-93	Spool and Bearings.....	155
Wireless (Vis).....	15, 67, 310	PASCObot.....	96	Structures Counterweight.....	157
Spectrometry Software.....	15, 311	PASCObot Sense & Control Kit.....	97-101	Structures Gripper.....	156
				Structures Hinge.....	157
				Turntable.....	156

Student Function Generator	274
Student Power Supply	272
Student Spectrometer	314
Student Timer	214
Suction Cup – see Air Pressure Demo	201
Superconductor – 4-Point, Wired	265
Medium, Standard	265
Large, Standard	265
Medium, Enhanced	265
Large, Enhanced	265
Large, Extra Strong Enhanced	265
Medium Extended Duration	265
Large Extended Duration	265
Super-Flex I-Beam	179
Super Pulley	149, 203
Super Pulley Force Table	145
Super Pulley with Clamp	121, 149, 203
Super Pulley with Mounting Rod	33, 149, 203
Support Rods and Base	204-205
Support, Technical	Inside Back Cover
Switch Set, Knife	247
Swivel Clamp	207
Sympathetic Resonance Box Set	287

- T -

Table Clamp, Large	207
Table Rod Clamp	207
Table, Force	145
Tank, Ripple	292-293
Tape, Measuring	208
Tape, Photogate	33, 123
Tape, Photogate High Resolution	33, 123
Tape Timer	127
Tape Timer Supplies	127
Teacher Training – see PASCO Portal	2-3
Teacher Guides – Comprehensive 850 Physics	72
Universal 550 Physics	75
Technical Support	Inside Back Cover
Technical Tuning Fork Set	287
Telescope/Microscope Experiment	383
Temperature Sensor – Absolute Pressure-Temp, PASPORT	39
Absolute Pressure-Temp, Wireless	4, 57
Fast Response Probe, PASPORT	40, 59
Non-Contact, PASPORT	41, 225
Quad, PASPORT	40
PASPORT	39-41
ScienceWorkshop	28
Skin/Surface Probe	40, 59
Stainless Steel Probe	40, 59
Temperature Link, Wireless	59
Thermocouple w Display (OLED), Wireless	4, 59, 225
Type K Probe	41
Wireless Temp	58
Wireless Temp w Display (OLED)	58
Wireless Abs. Temp. w Display (OLED)	4, 57
Tensile Samples, Materials Tester	174
Tensile Tester	172-179

Tensile Testing of Metals	172-179
Tension Protractor	146, 209
Test Coupons, Stress/Strain	178-179
Test Leads, Alligator Shrouded	249
Thallium-238	337
Thermal Conductivity Apparatus	218
Thermal Expansion Apparatus	216
Thermal Expansion Bimetallic Strip	217
Thermal Expansion Ring and Ball	217
Thermal Radiation Cans	226
Thermal Radiation Cube – see Leslie's Cube	6, 227
Thermal Radiation Lab	227
Thermal Radiation Sensor	226
Thermocouple Probe (Multimeter)	250
Thermocouple w Display, Wireless	4, 59, 225
Thermoelectric Converter	224
Thermometers – Constant Volume Gas, see Absolute Zero Sphere	222
Partial Immersion	225
Thread, Black	210
Three-Axis Acceleration Altimeter	55
Three-Finger Clamp	206
Three-Point Bending	177
Ticker-Tape Timer	127
Time-of-Flight Accessory	27, 33, 139, 141
Timer, Student – Photogate Timer	126
Smart Timer	124-125
Stopwatch, Digital	127, 214
Tape Timer	127
Top – see PhiTOP	201
Torsion Bands – Replacement Gravitational	330
Torque – see Meter Stick Torque	104, 148
Torque and Rotational Motion Kit	195
Total Internal Reflection – see Optical Fiber Model	308
Tower, Shaking	168, 359
Toys, Physics – Air Cannon	201
Bounce/No Bounce Balls/Pad	210-211
Constant Velocity Car	119
Doppler Rocket	286
Flying Airplane	191
Glow String	210, 287
Hover Puck	132
PhiTOP	201
Popper	181
Slinky, Double-length	182, 286
Sound Pipe	286
Track String Adapter, Rotary Motion	120
Track, Air	128-129
Track, Dynamics	108-109, 118-121, 290
Track Mount for Rotary Motion Sensor	120
Track, Optics	294
Track Rod Clamp	119
Track, Roller Coaster	130
Training – see PASCO Portal	2-3
Transformer Coils	6, 256-257

Translator, Linear	303
Transmitter Probe, Microwave	322
Transverse Wave Demonstrator	284
Trigger Dropper, Smart Cart	115
Triple-Output Power Supply	272
Triple-Beam Balance	212
Truss Set	160, 171
Tube, Resonance	282
Tunable DC Power Supply	270-271
Tuning Fork Set	287
Tungsten Balls, Gravitational Torsion	330
Turbine Generator	253
Turntable (Motorized Structures)	156
Type K Temperature Sensor	41

- U -

Ultrasonic Motion Detector	53
Ultraviolet Beads	315
Ultraviolet Flashlight	315
Ultraviolet Light Sensor – see Wireless Light & Color Sensor	63, 318
Universal 550 Physics – Experiment Bundle	75
Universal Gravitational Constant	330
Universal Gravitational Constant Experiment	349
Universal Interfaces – 550	18-19, 23-25
850	18-21, 24-25
850 Expansion Board	21
Universal Table Clamp	207
Utility/Buret Clamp	206
UV Beads	315
UV Flashlight	315
UVA Light Sensor – see Wireless Light & Color Sensor	63, 318
UV-Vis Fiber Optic Kit	66
UV-Vis Spectrometer	15, 66, 310

- V -

Vacuum, Bell Jar	285
Vacuum Pump, Hand-Operated	320
Van de Graaff Generator	228-229
Variable Capacitor	233
Variable Gap Lab Magnet	255
Variable Output Air Supply	129
Variable Speed Motorized Cart	116
Vector Display, Smart Cart	116
Vectors – see Force Table	145
Vectors, Video Analysis	8-11, 175
Velocity Car, Constant	119
Velocity Cart, Constant – see Smart Cart Motor	116
Venturi Tubes	45, 199-200
VI Sensor	43
Vibrations, Bridge Experiment	360
Vibrating String Experiment	381
Vibrator, String	278
Video Capture and Analysis	8-11, 175
Visual Accelerometer – see Vector Display	116

Viewing Screen, Basic Optics.....	294	Wide Range Function Generator	271	Smart Gate.....	54, 122-123
Violin Chladni Plate	280	Wind Turbine, Energy Transfer.....	254	Sound	62
Voltage Sensors –		Wire Loop, Resonance	280	Spectrometer.....	67, 310
550 & 850	28-29	Wireless Diffraction	298-299	Thermocouple with Display (OLED) ..	4, 59, 225
//control.Node	90	Wireless Interfaces.....	18-19	Temperature	58
PASPORT	43	Wireless Sensor Adapter –		Temperature Link.....	59
ScienceWorkshop	28-29	see AirLink	18, 50	Temperature with Display (OLED).....	58
Shrouded	28	Wireless Sensor Charger	69	Temperature-Pressure with	
Unshrouded.....	29	Wireless Sensor Packs	69	Display (OLED)	4, 57
Wireless.....	60	Wireless Sensor Storage Trays.....	69, 213	Voltage.....	60
Voltage Source, Electrostatics.....	233	Wireless Sensors –		Voltage-Current with Display (OLED)	4, 61
Voltage-Current Sensor, PASPORT	43	Absolute Pressure-Temperature with		Wireless Smart Carts	52, 106-117
Voltage-Current Sensor, Wireless w Display..	4, 61	Display (OLED).....	4, 57	Wireless Spectrometer	67, 310
Voltaic Cell	251	AC/DC Module.....	239	Wires, Resistance Replacement.....	235
Voltmeter, Analog	28, 232	Acceleration/Altimeter	55	Work Energy Theorem Experiment	348
Volumetric Flow Rate –		Charge	62, 231	Workshop Physics –	
see General Flow Sensor.....	45, 199-200	//code.Node	68, 84-86, 98, 100	Chaos Accessory	197, 356
– W –					
Wand, Induction.....	255	//control.Node	68, 84, 88, 93-97, 152-154	Coils, Detector and Field	256-257
Wands, Rotational Inertia.....	192	Current	60	Equal Arm Balance	144
Water Flow	45, 198-200	Current Module	60, 237	Heat Engine/Gas Law Apparatus.....	223
Water Reservoir	213	Current-Voltage w Display (OLED).....	4, 61	– X –	
Water Velocity	45, 199-200	Dynamometer, Hand	4, 55	Xenon Strobe.....	216, 278
Waterproof Caliper, Optics	208	Electrostatics System.....	231	X-Y Adjustable Laser	317
Wave Cord, Elastic.....	210, 286	Force Acceleration	55	XYZ Connector Spares,	
Wave Driver.....	280	Force Platforms	56	Full Round.....	171
Wave Motion Demonstrator	284	Geiger Counter	65, 336	– Y –	
Wave Spring, Demonstration.....	182, 280	Hand Dynamometer	4, 55	Yellow Cord	210
Waves and Sound,		Light & Color	63, 318	Young's Modulus –	
Physics Lab Station	81	Load Cell.....	55, 159	see Materials Testing	172-179
Waves Experiment	380	Magnetic Field.....	64	– Z –	
Web Application, Progressive (PWA) –		Motion	53	Zeeman Effect.....	329, 392
see SPARKvue Software	13	Pressure	57	Zero, Absolute	222
Wheel/Axle Replacement Set.....	120	Pressure-Temp w Display (OLED).....	4, 57	Zero Gauss Chamber	30, 44, 64, 266
Wheel, Caster	156	Rotary Motion.....	53		
		Smart Carts.....	52, 106-117		

Learn more about PASCO's complete line of sensors at pasco.com



ISO 9001 Certified

PASCO has been supporting educators in over 100 countries around the world since 1964.

ISO 9001 Quality Certification

PASCO scientific meets the highest quality standards, and our quality management system is registered to ISO 9001. For more information, refer to pasco.com/about-us/iso-certification

Free Teacher and Technical Support

We want teachers to be successful with PASCO solutions. Please contact our support team with any questions at pasco.com/support, or via phone: 800-772-8700 (inside US); +1 916-786-3800 (outside US) or email: support@pasco.com

Terms of Purchase

For online access to read FCC, CE MARK, and other product regulations, refer to pasco.com/p/terms-of-purchase

Shipping

Items in stock (if stock is available) will normally be shipped in less than two working days from receipt of that order. Specific request for air shipments or special carriers will be honored at additional cost.

Warranty & Returns

For online access to read PASCO's 90-Day Satisfaction Guarantee, PASCO's 5-Year Limited Warranty for Education, and Returns for inside and outside the US, refer to pasco.com/p/warranty-and-returns

Products manufactured by anyone other than PASCO are subject to the conditions of the warranty supplied by the manufacturer (generally 1 year). Additional warranty information on our products is available upon request.

Trademarks & Patents

For online access to trademarks, registered trademarks, and patents of PASCO scientific in the United States and/or other countries, refer to pasco.com/p/trademarks-and-patents

Software Licenses Agreement

For online access to the complete EULA, refer to pasco.com/p/education-software

eBook Usage Agreement

PASCO eBooks consist of Essential Physics and/or Essential Chemistry curriculum. For online access to the complete usage agreement, refer to pasco.com/p/ebook-eula

PASCO OpenSciEd Agreement

For online access to the complete EULA for the PASCO Certified Version of OpenSciEd K-12 curriculum, refer to pasco.com/p/openscienced-eula

PASCO and The Environment

For online access to the PASCO Environmental Policy including RoHS, WEEE-Product End of Life Disposal Instructions, and Battery Replacement and Disposal Instructions, refer to

pasco.com/about-us/pasco-and-the-environment



For more complete information, refer to www.pasco.com/legal

Global Coverage & World-Class Support

PASCO

PASCO's global network of factory-trained partners are science specialists who are knowledgeable about PASCO solutions. Contact our team today to see how PASCO can update your labs and provide value for years to come.

Find Your Local Representative
pasco.com/support

Follow PASCO:



Live Contact Hours:

M–Th: 7:00 am–4:30 pm
F: 7:00 am–2:00 pm
Pacific Time



Phone:

+1 916.786.3800 (outside US)
800.772.8700 ext. 1004
(inside US)
Fax: 916.786.7565



Mail:

PASCO Scientific
10101 Foothills Blvd.
Roseville, California
95747-7100 USA
ISO 9001:2015 Certified



Email:

support@pasco.com



Web:

Get quotes and
order online
pasco.com



Chat on pasco.com

Providing educators worldwide with innovative solutions for teaching science.

PASCO

10101 Foothills Blvd.
Roseville, CA 95747-7100

800-772-8700

www.pasco.com

Change Service Requested

PRSRT BPM
US POSTAGE
PAID
KENT, OH
PERMIT #15

Keeps Getting *Smarter!* The Amazing Wireless Smart Cart

THE ORIGINAL
Patent No. 10481173



Five Built-In Wireless Sensors
Innovative Accessories
Convenient Kits



Trigger Dropper



Smart Cart Motor



Fan Accessory



Vector Display



Ballistic Cart Accessory



Ball Catcher

