PASCO Experiments

The following pages present classic experiments in physics performed with PASCO apparatus. Everything is included in the experiment; apparatus, sensors (when needed), and accessories. Manuals can be downloaded at www.pasco.com. Interfaces, where indicated, should be ordered separately.

Downloads Available

Each experiment manual and the DataStudio files may be downloaded free at

www.pasco.com

Type the experiment number EX-xxxx into the search box to find the download information:

- **Experiment Manual:** A detailed experiment manual ensures student success. An electronic Word® version is included for modification by the teacher.
- **DataStudio File:** DataStudio files are included for each experiment. These files contain all the displays, calculations and analysis tools needed for the experiment. Use these files with students. A file with sample data is also included.

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Atwood's Machine

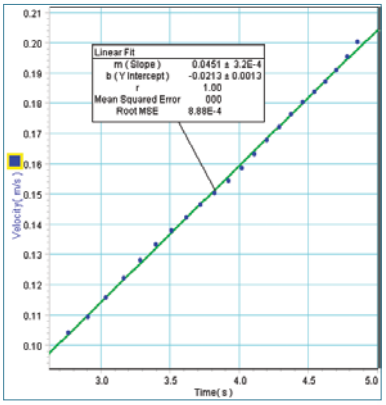
EX-9973 *ScienceWorkshop*

NEW

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 and measure the changing velocity of the unbalanced mass system. They interpret the slope of the velocity graph as acceleration. They examine the effect of the rotational inertia of the pulley and estimate the friction forces based on experimental data.



The acceleration of the weights is determined using the slope of the velocity vs. time graph and, from this, the acceleration due to gravity can be found.

Experiment Includes:

Super Pulley with Mounting Rod	ME-9499
Photogate Head	ME-9498A
Mass and Hanger Set	ME-8979
Universal Table Clamp	ME-9376B
Threaded Rod 60cm	ME-8977
Multi-Clamp	SE-9442
Braided Physics String	SE-8050
Atwood's Machine/Newton's 2nd Law Experiment Manual	
DataStudio Files for Atwood's Machine/Newton's 2nd Law Experiment	
DataStudio Lite Software	

NEW **Downloads Available**

Each experiment manual and the DataStudio files may be downloaded free at **www.pasco.com**

Type the experiment number EX-XXXX into the search box to find the download information.

Order Information:

Atwood's Machine/Newton's 2nd Law **EX-9973**

Required for use with ScienceWorkshop:

ScienceWorkshop 500 or *750* Interface ..... p. 68-72

DataStudio Software ..... p. 86-89

Balance or Scale ..... p. 222

Calipers ..... SE-8710 p. 218

Projectile Motion

EX-9948

Concepts:

- Independence of x and y Motion
- Muzzle Velocity vs. Time of Flight
- Angle vs. Horizontal Range

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 time of flight is not related to muzzle velocity at 0˚ launch angle.

Angle vs. Horizontal Range

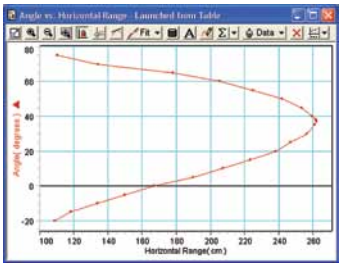
The angle of launch is varied and the horizontal range measured for each angle. Students produce a graph of angle vs. horizontal range. The angle of maximum range can then be found. This experiment is conducted for two cases:

- 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 kinematics equations to predict the horizontal range given a launch angle and muzzle velocity. Carbon paper and a bulls-eye can then be used to test their hypothesis.

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 kinematics equations to be empirically verified.



Students can use their data to determine which launch angle produces the maximum horizontal range.

The Photogate and Time of Flight Accessory are used with the Mini Launcher to measure both muzzle velocity and time of flight.

Experiment Includes:

Mini Launcher	ME-6825
Smart Timer	ME-8930
Time-of-Flight Accessory	ME-6810
Photogate Head (2)	ME-9498A
Photogate Bracket	ME-6821
Universal Table Clamp	ME-9376B
Carbon Paper	SE-8693
Metric Measuring Tape	SE-8712A
Projectile Motion Experiment Manual	
DataStudio Files for Projectile Motion Experiment	
DataStudio Lite Software	

NEW **Downloads Available**

Each experiment manual and the DataStudio files may be downloaded free at **www.pasco.com**

Type the experiment number EX-XXXX into the search box to find the download information.

Order Information:

Projectile Motion **EX-9948**

Newton's Laws

EX-9940 *ScienceWorkshop*
EX-9941 PASPORT

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, Force Sensor and Motion Sensor.

Method

Students use this collection of equipment to discover or experimentally determine all three of Newton's Laws.

Newton's First Law – Students use a Motion Sensor to collect data for various sliding, rolling and hovering objects. Using the data and their observations, students better understand that an object's motion will not change unless acted upon by an external net force.

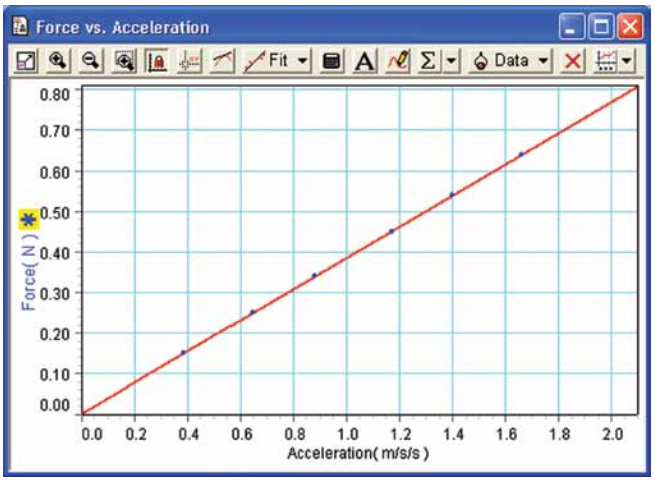
Newton's Second Law – Students use a Force Sensor and Motion Sensor with PASCO's Dynamics System to discover the relationships between force, mass and acceleration.

Newton's Third Law – Using two 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

Using this set of equipment and probeware, students will better understand all three of Newton's Laws. The integration between the probeware and equipment helps students focus on the physics of each experiment.

Experiment Includes:	EX-9940 *ScienceWorkshop*	EX-9941 PASPORT
PAScar Dynamics System	ME-6955	ME-6955
Force Sensor (2)	CI-6746	PS-2104
Motion Sensor	CI-6742	PS-2103
Hover Puck	SE-7335	SE-7335
Discover Friction Accessory	ME-8574	ME-8574
Smart Pulley with Clamp	ME-9448A	ME-9448A
Mass and Hanger Set	ME-9348	ME-9348
Physics String	SE-8050	SE-8050
Newton's Laws Experiment Manual		
DataStudio File for Newton's Laws Experiment		
DataStudio Lite Software		



Force vs. acceleration data for the PAScar as it experiences changing net force.

NEW **Downloads Available**

Each experiment manual and the DataStudio files may be downloaded free at **www.pasco.com**
Type the experiment number EX-XXXX into the search box to find the download information.

Order Information:

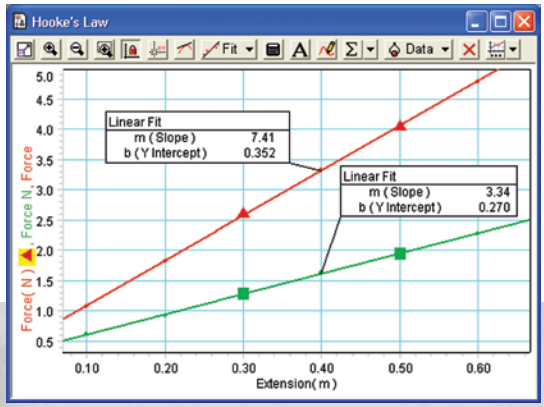
Newton's Laws (*ScienceWorkshop*) **EX-9940**
Newton's Laws (PASPORT) **EX-9941**
Required for use with ScienceWorkshop:
ScienceWorkshop 500, 700 or *750* Interface ..... p. 68-72
Required for use with PASPORT:
PASPORT Interface ..... p. 10-23

Hooke's Law

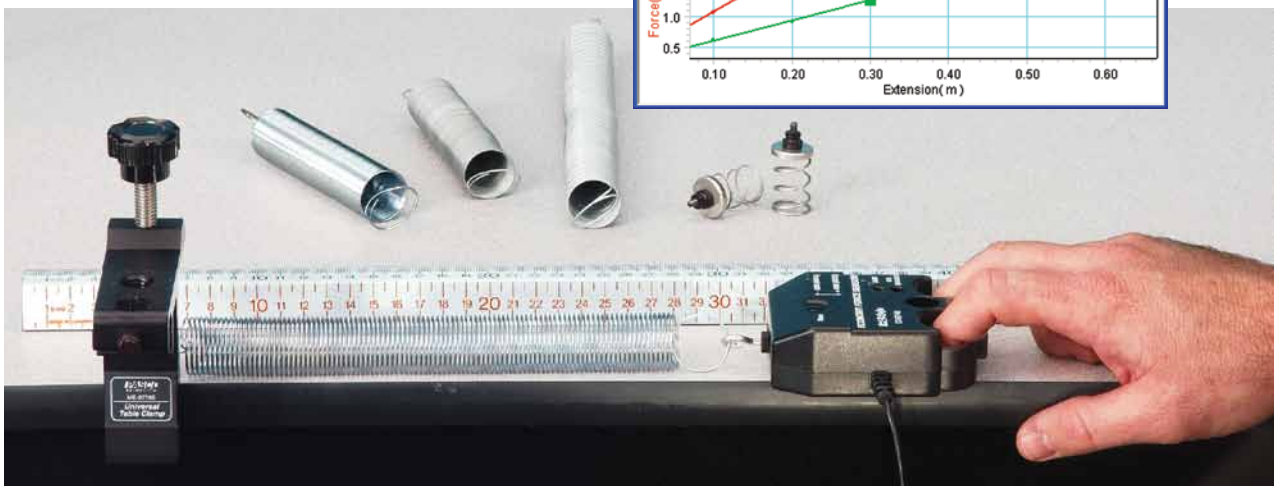
EX-9947 *ScienceWorkshop*
EX-9951 PASPORT

Concepts:

- Relationship between Force and Spring Deformation
- Investigate both Spring Compression and Extension



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.



Method

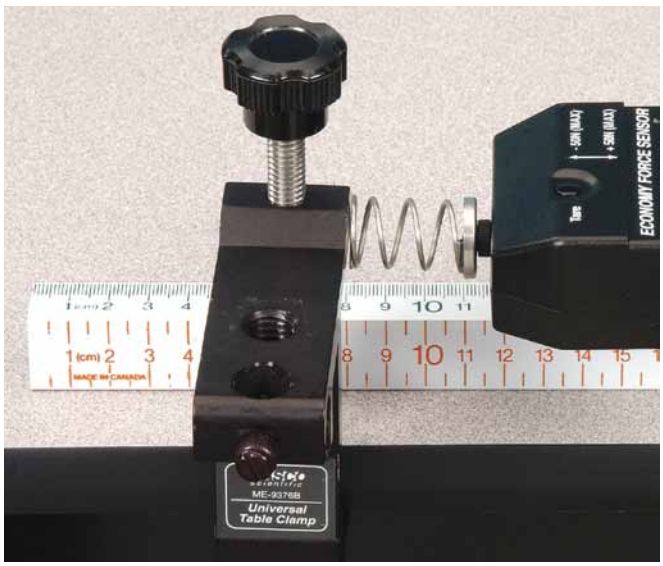
In this experiment, students use a Force Sensor to measure the force exerted to either compress or extend various springs. The stretch or compression of the spring is measured directly from a meter stick. The manual sampling feature of DataStudio® allows students to save measurements of force for each of the chosen deformations of the spring.

Once the data is collected, students can easily create a Force vs. Stretch (or Compression) graph by dragging their table of data to the Graph icon. 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.

PASCO Advantage

The 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 are applying the forces to the springs and will have a better kinesthetic feel for the amount of force being applied in each case.



Real-time force measurements are collected as the spring is compressed.

Experiment Includes:	EX-9947 *ScienceWorkshop*	EX-9951 PASPORT
Demonstration Spring Set	ME-9866	ME-9866
Force Sensor	CI-6746	PS-2104
Universal Table Clamp	ME-9376B	ME-9376B
Heavy Spring Bumper	003-09925	003-09925
Light Spring Bumper	003-09926	003-09926
Four-Scale Meter Stick	SE-8695	SE-8695
Hooke's Law Experiment Manual		
DataStudio Files for Hooke's Law Experiment		
DataStudio Lite Software		

NEW **Downloads Available**

Each experiment manual and the DataStudio files may be downloaded free at **www.pasco.com**
Type the experiment number EX-XXXX into the search box to find the download information.

Order Information:

Hooke's Law (*ScienceWorkshop*) **EX-9947**
Hooke's Law (PASPORT) **EX-9951**
Required for use with ScienceWorkshop:
ScienceWorkshop 500, 700 or *750* Interface ..... p. 68-72
Required for use with PASPORT:
PASPORT Interface ..... p. 10-23

Centripetal Force on a Pendulum

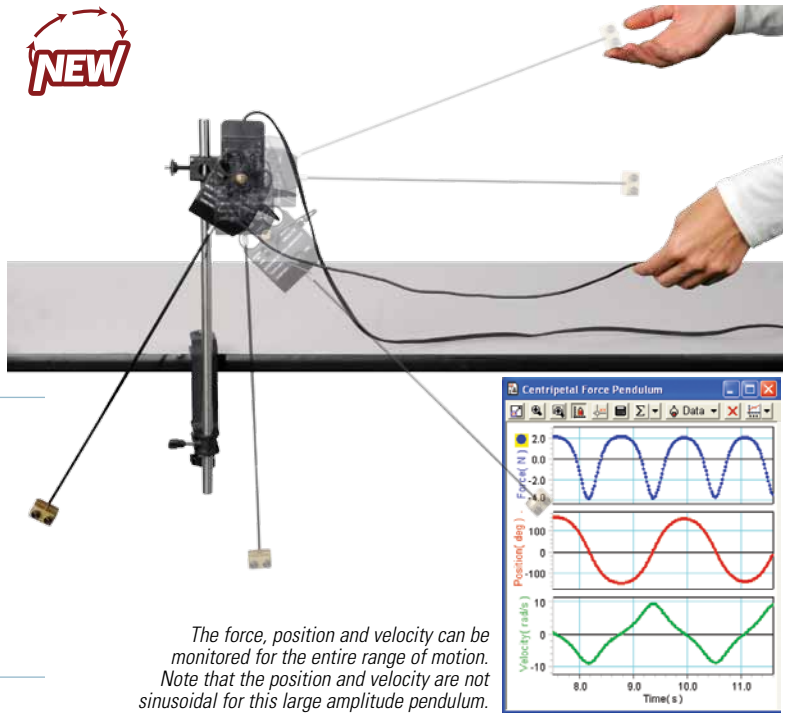
EX-9974 *ScienceWorkshop*

NEW

Concepts:

- Centripetal Force
- Angular Velocity
- Periodic Motion

Students explore the relationship between mass, radius of rotation, angular velocity and centripetal force. By continuously measuring the force and angular velocity students see not just peak values but also how these change during the entire motion of the pendulum. Students 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.

Experiment Includes:

Economy Force Sensor	CI-6746
Rotary Motion Sensor	CI-6538
Centripetal Force Pendulum	ME-9821
Aluminum Table Clamp	ME-8995
Steel Rod 45 cm	ME-8736
Centripetal Force on a Pendulum Experiment Manual	
DataStudio File for Centripetal Force on a Pendulum Experiment	
DataStudio Lite Software	

NEW **Downloads Available**

Each experiment manual and the DataStudio files may be downloaded free at **www.pasco.com**

Type the experiment number EX-XXXX into the search box to find the download information.

Order Information:

Centripetal Force on a Pendulum **EX-9974**

Required for use with ScienceWorkshop:

ScienceWorkshop 500 or *750* Interface ..... p. 68-72

DataStudio Software ..... p. 86-89

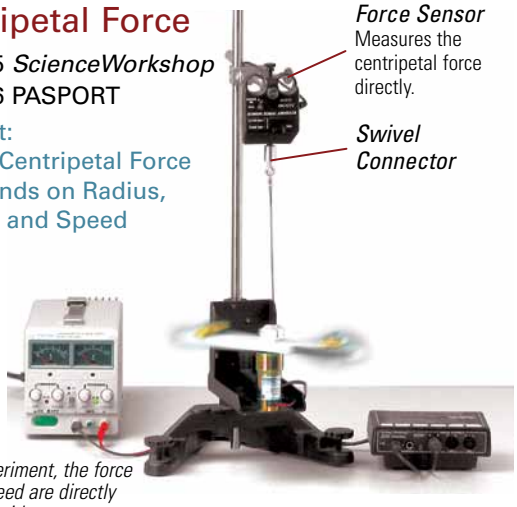
Centripetal Force

EX-9925 *ScienceWorkshop*

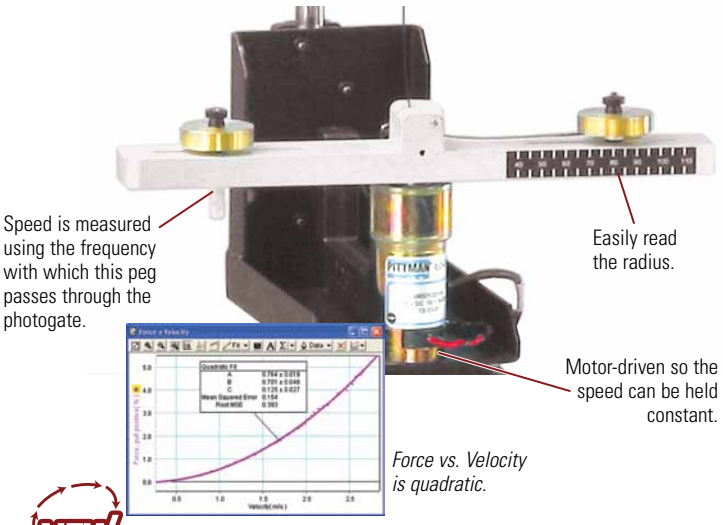
EX-9926 PASPORT

Concept:

- How Centripetal Force Depends on Radius, Mass and Speed



In this experiment, the force and the speed are directly measured with sensors.



Force vs. Velocity is quadratic.

Experiment Includes:

	EX-9925 *ScienceWorkshop*	EX-9926 PASPORT
Centripetal Force Apparatus	ME-8088	ME-8088
Economy Force Sensor	CI-6746	PS-2104
Photogate Head	ME-9498A	ME-9498A
Digital Adapter	*not required*	PS-2159
Large Rod Stand	ME-8735	ME-8735
90 cm Steel Rod	ME-8738	ME-8738
Multi Clamp	SE-9442	SE-9442
45 cm Steel Rod	ME-8736	ME-8736
Triple Output Power Supply	SE-8587	SE-8587
Centripetal Force Experiment Manual		
DataStudio File for Centripetal Force Experiment		
DataStudio Lite Software		

NEW **Downloads Available**

Each experiment manual and the DataStudio files may be downloaded free at **www.pasco.com**

Type the experiment number EX-XXXX into the search box to find the download information.

Order Information:

Centripetal Force (*ScienceWorkshop*) **EX-9925**

Centripetal Force (PASPORT) **EX-9926**

Required for use with ScienceWorkshop:

ScienceWorkshop 500 or *750* Interface ..... p. 68-72

DataStudio Software ..... p. 86-89

Required for use with PASPORT:

PASPORT Interface ..... p. 10-23

DataStudio Software ..... p. 86-89

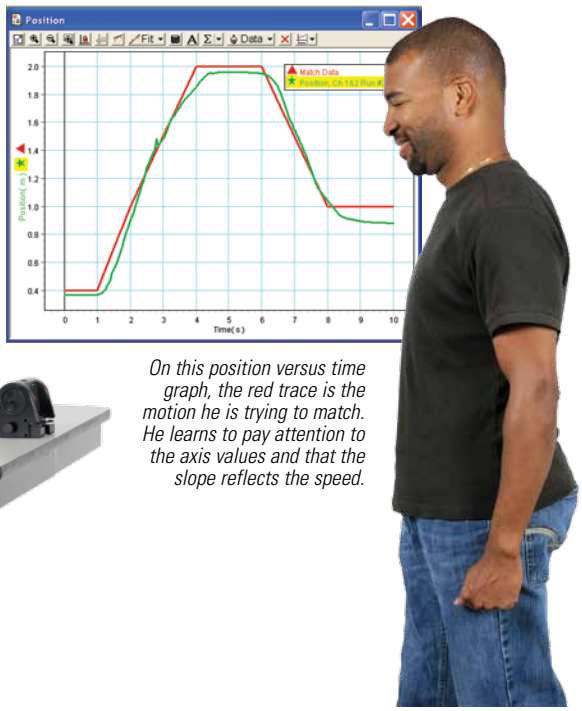
Motion Graph Matching

EX-9975

Concepts:

- Position vs. Time Graph
- Velocity vs. Time Graph
- Meaning of Slope and Inflection Point

Students explore the relationship between their motion walking toward and away from a motion sensor and graphs of position and velocity. They are challenged to match a predetermined graph and explain what the meaning of slope and inflection points on the graph of their movements mean.



On this position versus time graph, the red trace is the motion he is trying to match. He learns to pay attention to the axis values and that the slope reflects the speed.

Experiment Includes:

Motion Sensor II	CI-6742A
Motion Sensor II Experiment Manual	
DataStudio File for Motion Sensor II Experiment	
DataStudio Lite Software	

Downloads Available

Each experiment manual and the DataStudio files may be downloaded free at **www.pasco.com**

Type the experiment number EX-XXXX into the search box to find the download information.

Order Information:

Motion Graph Matching **EX-9975**

Required for use with ScienceWorkshop:

ScienceWorkshop 500 or *750* Interface ..... p. 68-72

DataStudio Software ..... p. 86-89

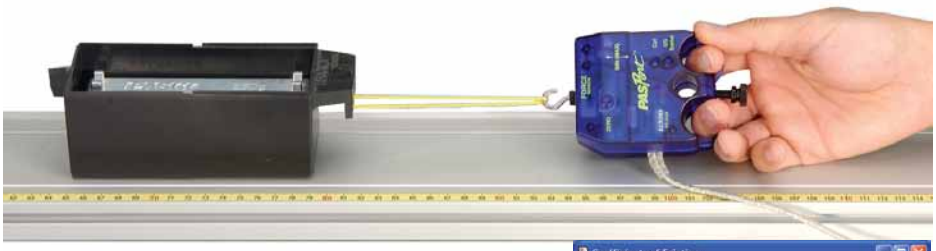
Sliding Friction

EX-9938 *ScienceWorkshop*

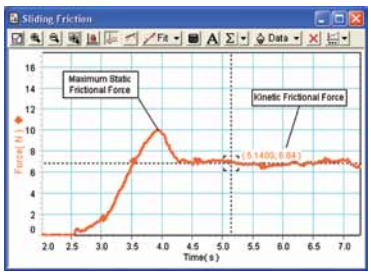
EX-9939 PASPORT

Concepts:

- Relationship between Frictional Force and Normal Force
- Coefficients of Friction (Kinetic and Static)

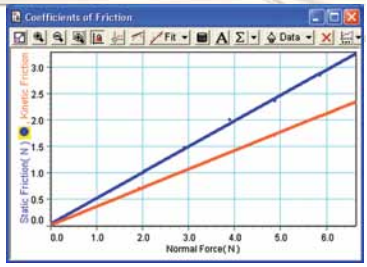


Students pull the friction tray from rest to a constant velocity to measure both static and kinetic friction.



The peak of the graph represents the maximum static frictional force. Once the friction tray begins to move, the kinetic frictional force is evident on the graph.

In this experiment, students use a Force Sensor to discover frictional forces and their effect on the motion of an object. In addition, the coefficients of friction for various surface combinations can be empirically determined.



Students create a graph of frictional force vs. normal force to find the coefficients of static and kinetic friction.

Experiment Includes:	EX-9938 *ScienceWorkshop*	EX-9939 PASPORT
Discover Friction Accessory	ME-8574	ME-8574
Force Sensor	CI-6746	PS-2104
500 g Cart Masses (4)	648-04636	648-04636
Physics String	SE-8050	SE-8050
Sliding Friction Experiment Manual		
DataStudio File for Sliding Friction Experiment		
DataStudio Lite Software		

Downloads Available

Each experiment manual and the DataStudio files may be downloaded free at **www.pasco.com**

Type the experiment number EX-XXXX into the search box to find the download information.

Order Information:

Sliding Friction (*ScienceWorkshop*) **EX-9938**

Sliding Friction (PASPORT) **EX-9939**

Required for use with ScienceWorkshop:

ScienceWorkshop 500, 700 or *750* Interface ..... p. 68-72

Required for use with PASPORT:

PASPORT Interface ..... p. 10-23

Impulse

EX-9902 *ScienceWorkshop*

Concepts:

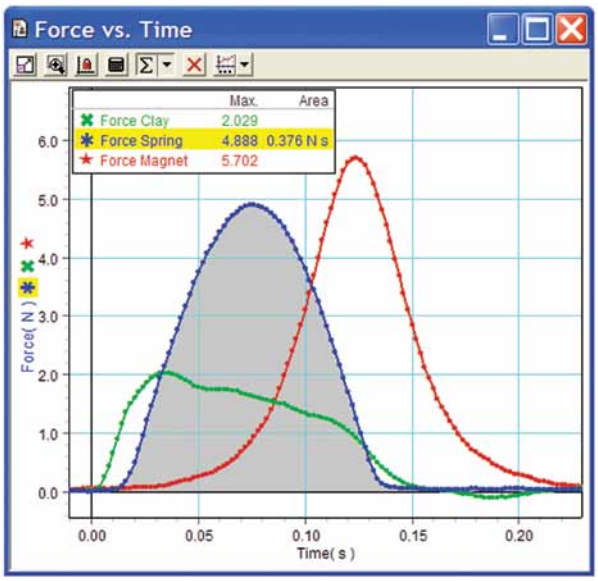
- Impulse: Change in Momentum
- Impulse: Area Under a Force Versus Time Curve
- Different Shaped Force Curves for Elastic and Inelastic Collisions

The impulse of a collision is determined by two methods.

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 versus time curve.

A cart runs down a slightly inclined track and collides with a Force Sensor equipped with either a clay bumper, spring bumper or magnetic bumper. To determine the change in momentum (impulse), the speeds before and after the collision are recorded with a photogate. The photogate is also used to trigger the beginning of data collection for the Force Sensor. To confirm the impulse, the force versus time is plotted and the impulse is determined by finding the area under the curve.

Different shaped curves of force versus time are obtained for the different bumpers. The spring and magnetic bumpers result in nearly elastic collisions while the clay produces a completely inelastic collision. The area under the clay force curve is half the area under the spring or magnetic force curves because the cart does not rebound in the clay collision.



The force versus time is shown for three different bumpers: Clay bumper in green, spring bumper in blue and magnetic bumper in red.

Close-up of magnetic bumper.

PASCO Advantage

Since DataStudio is capable of having start and stop conditions, force data can be collected at a high rate during the collision, showing the force in great detail without a lot of extraneous data before and after the collision. The data collection starts when the cart passes through the photogate and ends after a set amount of time.

Experiment Includes:

1.2 m PAScar Dynamics System	ME-6955
Force Accessory Bracket	CI-6545
IDS Photogate Bracket	ME-9806
Photogate Head	ME-9498A
Force Sensor	CI-6537
Picket Fence	648-06817
Impulse Experiment Manual	
DataStudio File for Impulse Experiment	

NEW Downloads Available

Each experiment manual and the DataStudio files may be downloaded free at **www.pasco.com**

Type the experiment number EX-XXXX into the search box to find the download information.

Order Information:

Impulse **EX-9902**

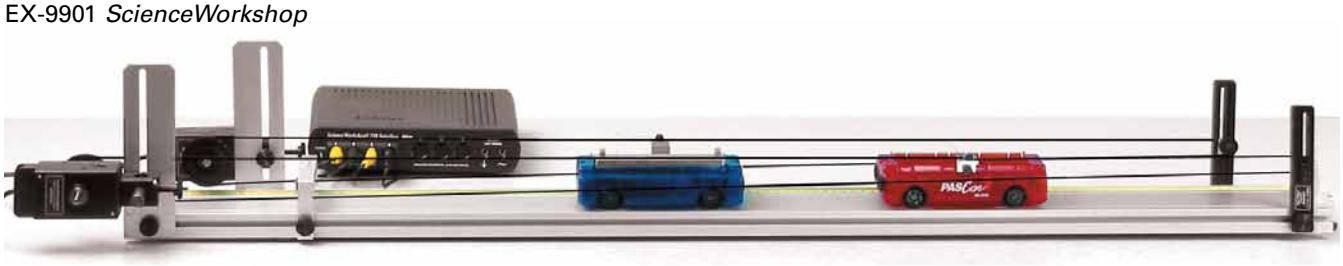
Required:

ScienceWorkshop 500, 700 or *750* Interface ..... p. 68-72

DataStudio Software ..... p. 86-89

Conservation of Momentum

EX-9901 *ScienceWorkshop*



Cart velocities are recorded using two Rotary Motion Sensors connected to the carts by string wrapped around pulleys. The moving cart rotates the pulley on the Rotary Motion Sensor, recording the cart's position with a resolution of 0.4 mm.

Concepts:

- Conservation of Momentum in Elastic and Inelastic Collisions
- Kinetic Energy not Conserved in Inelastic Collisions
- Kinetic Energy 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 two Rotary Motion Sensors connected to the carts by string wrapped around pulleys. This measurement method adds very little friction to the experiment and, since the velocities are continuously monitored, any deceleration due to friction can be measured.

A real-time graph of velocity versus 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.

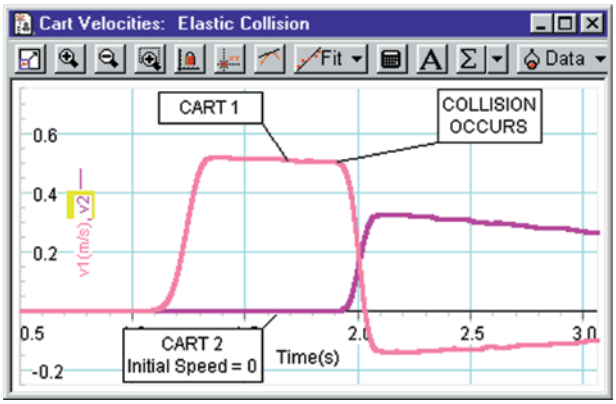
The kinetic energy before and after the collision is also studied. Kinetic energy is not conserved for inelastic collisions. It is also demonstrated that kinetic energy momentarily decreases during the elastic collision and then returns to the original value after the collision.

PASCO Advantage

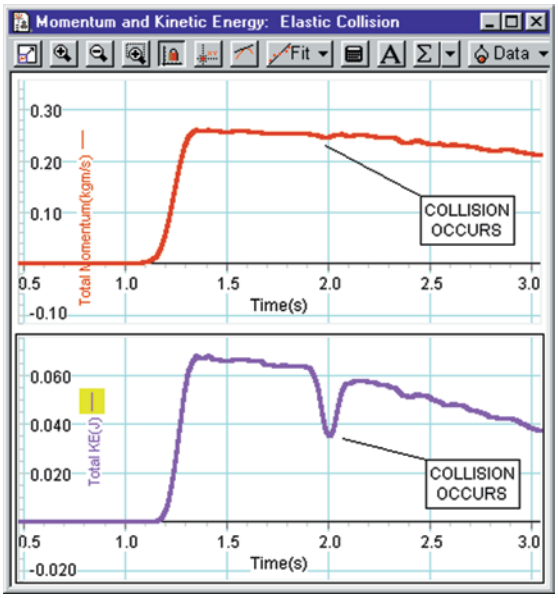
The magnitude and direction of the velocity of each cart is recorded continuously throughout the collision, eliminating the problem in older methods, of positioning photogates too close or too far from the point of collision.

Experiment Includes:

2.2 m PAScar Dynamics System	ME-6956
Dynamics Track Mount (2)	CI-6692
RMS/IDS Adapters (2)	ME-6569
Rotary Motion Sensors (2)	CI-6538
Conservation of Momentum Experiment Manual	
DataStudio File for Conservation of Momentum Experiment	



A real-time graph of velocity versus time is obtained for each cart, clearly showing when the elastic collision occurred.



The top graph of the total momentum for the 2-cart system (as calculated in DataStudio) shows no change throughout the elastic collision. The total kinetic energy, shown in the bottom graph, momentarily decreases during the collision because energy is stored as magnetic potential energy.

NEW Downloads Available

Each experiment manual and the DataStudio files may be downloaded free at **www.pasco.com**

Type the experiment number EX-XXXX into the search box to find the download information.

Order Information:

Conservation of Momentum **EX-9901**

Required:

ScienceWorkshop 500, 700 or *750* Interface ..... p. 68-72

DataStudio Software ..... p. 86-89

Ballistic Pendulum

EX-9959 PASPORT

Concepts:

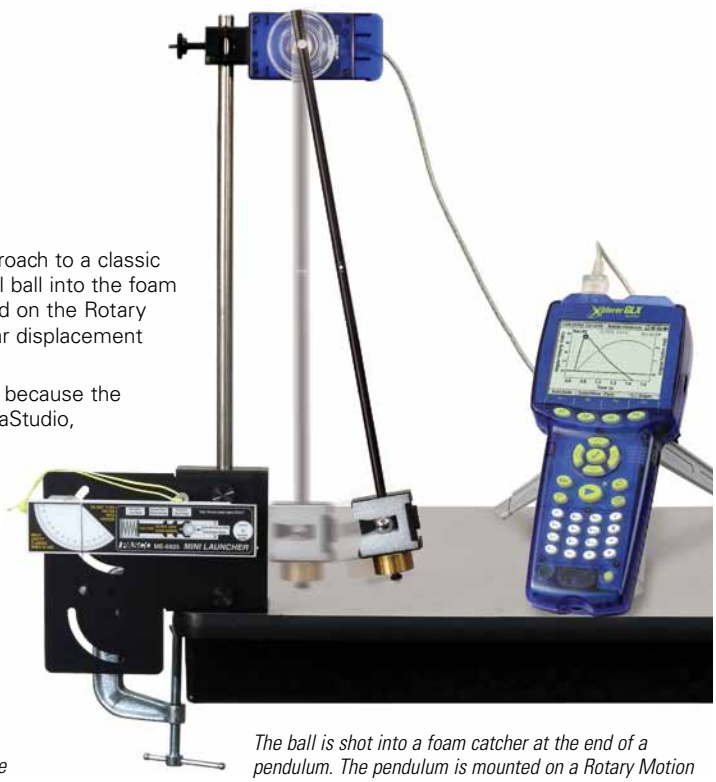
- Modern Approach to a Classic Experiment
- View Graph of Entire Pendulum Swing
- Conservation of Momentum
- Conservation of Energy

PASCO's Rotary Motion Sensor is the heart of this modern approach to a classic physics experiment. The Mini Launcher (ME-6825A) fires a steel ball into the foam catcher of the Ballistic Pendulum Accessory (ME-6829) mounted on the Rotary Motion Sensor. The Rotary Motion Sensor measures the angular displacement of the pendulum and it is plotted in real-time in DataStudio®.

There is no need to catch the pendulum at its maximum height because the angle is continuously measured. Using the analysis tools in DataStudio, students can find the maximum angle.

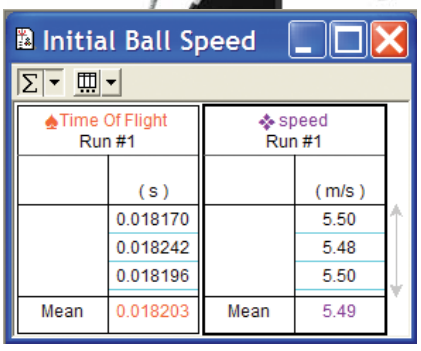
Using Conservation of Momentum and Conservation of Energy, students can determine the initial speed of the ball as it leaves the projectile launcher.

The initial speed of the ball is confirmed by using two photogates to time the flight of the ball for a short distance.

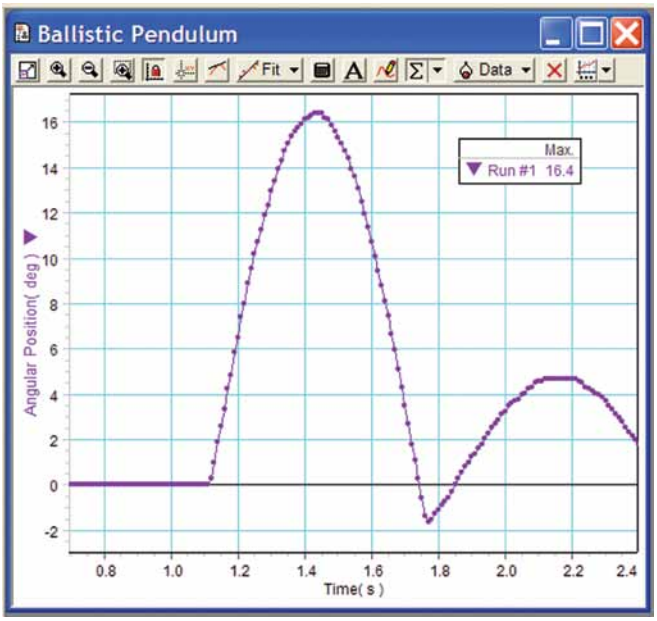


The ball is shot into a foam catcher at the end of a pendulum. The pendulum is mounted on a Rotary Motion Sensor to record the entire swing.

Two photogates are mounted at a fixed distance apart on the Projectile Launcher to measure the initial speed of the ball



The times between photogates and the calculated speeds for multiple trials are shown in this table.



This graph of the angle of the pendulum versus time is plotted in real time in DataStudio. The maximum angle is displayed in the graph legend.

Experiment Includes:

Rotary Motion Sensor	PS-2120
Mini Launcher	ME-6825A
Photogate Heads (2)	ME-9498A
Photogate Mounting Bracket	ME-6821A
Digital Adapter	PS-2159
Mini Launcher Ballistic Pendulum	ME-6829
Large Table Clamp	ME-9472
Steel Rod	ME-8736
Ballistic Pendulum Experiment Manual	
DataStudio Files for Ballistic Pendulum Experiment	
DataStudio Lite Software	

NEW Downloads Available

Each experiment manual and the DataStudio files may be downloaded free at **www.pasco.com**

Type the experiment number EX-XXXX into the search box to find the download information.

Order Information:

Ballistic Pendulum **EX-9959**

Required:

PASPORT Interface ..... p. 10-23

DataStudio Software ..... p. 86-89

Conservation of Energy

EX-9935

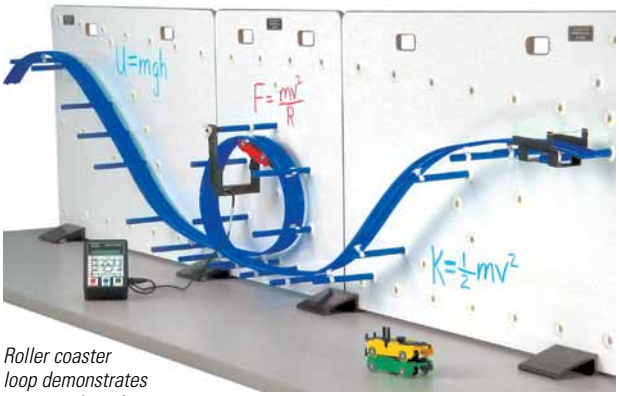
Concepts:

- 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 for 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 so it 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.

Experiment Includes:

Complete Roller Coaster System	ME-9812
Photogate Heads (2)	ME-9498A
Smart Timer	ME-8930
Conservation of Energy Experiment Manual	

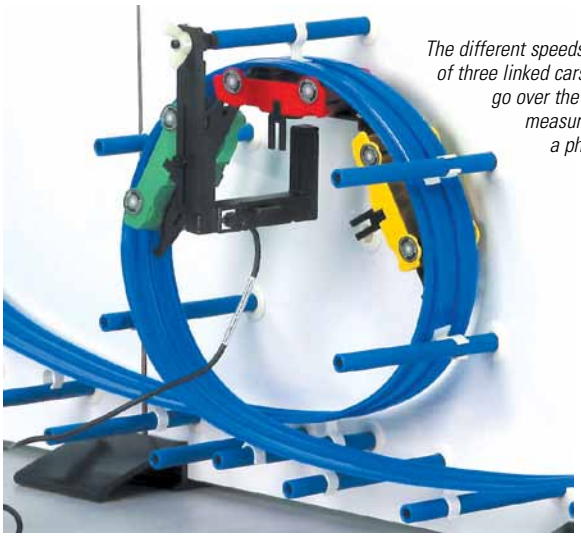
PASCO Advantage

The Roller Coaster can be configured in many ways. The white board 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

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.



The different speeds of each of three linked cars as they go over the loop are measured using a photogate.

NEW Downloads Available

Each experiment manual and the DataStudio files may be downloaded free at **www.pasco.com**

Type the experiment number EX-XXXX into the search box to find the download information.

Order Information:

Conservation of Energy EX-9935

Work Energy Theorem

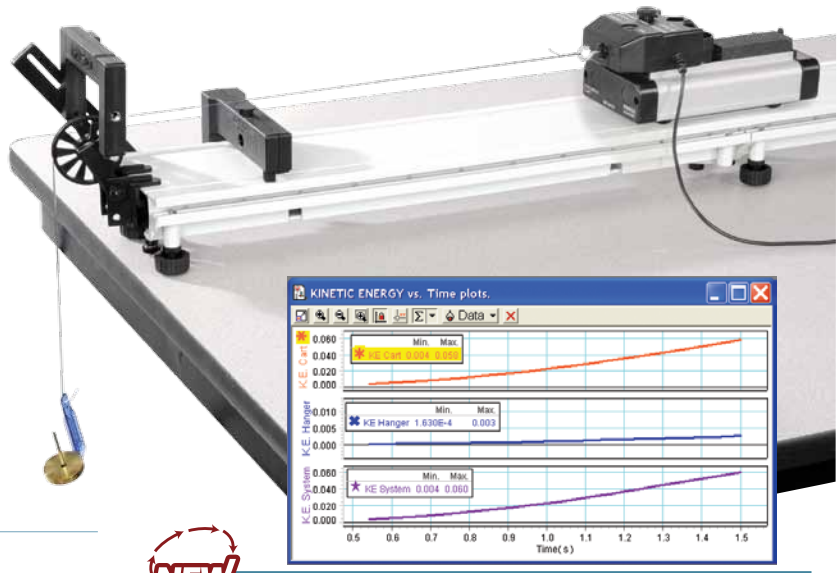
NEW

EX-9976 *ScienceWorkshop*

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 force sensor and photogate/pulley system, students record and display the force as a function of position and the work done is the area under the force vs. position plot. Kinetic energy, at any point during the experiment, is calculated from the velocity measured with the photogate and pulley. Students explore the meaning of dissipative forces.



Experiment Includes:

Economy Force Sensor	CI-6746
PAStrack Basic System	ME-6962
Compact Cart Mass	ME-6755
Photogate Head	ME-9498A
Photogate Bracket	ME-9806
Super Pulley with Clamp	ME-9448A
Mass and Hanger Set	ME-8979
Braided Physics String	SE-8050
Work Energy Theorem Experiment Manual	
DataStudio Files for Work Energy Theorem Experiment	
DataStudio Lite Software	

NEW **Downloads Available**

Each experiment manual and the DataStudio files may be downloaded free at **www.pasco.com**

Type the experiment number EX-XXXX into the search box to find the download information.

Order Information:

Work Energy Theorem **EX-9976**

Required for use with ScienceWorkshop:

ScienceWorkshop 500 or *750* Interface ..... p. 68-72

DataStudio Software ..... p. 86-89

Conservation of Energy II

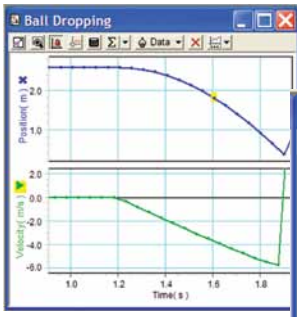
EX-9961 PASPORT

Concepts:

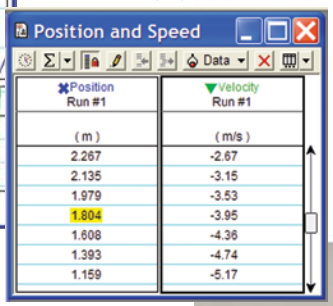
- Potential energy of a falling ball
- Kinetic energy of a falling ball
- Use different size balls to change friction

A ball is dropped from rest and its height and speed are recorded using a 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.



As the ball falls, its height and speed are recorded and displayed in DataStudio.



The height and speed of the ball at various points during the fall are used to calculate the potential energy and the kinetic energy.

Experiment Includes:

Motion Sensor	PS-2103A
Discover Freefall System	ME-9889
Large Rod Base	ME-8735
45 cm Rod	ME-8736
120 cm Rod	ME-8741
Multi-Clamp	SE-9442
Motion Sensor Guard	SE-7256
Mass Balance	SE-8707
Conservation of Angular Momentum Experiment Manual	
Xplorer GLX Files for Conservation of Angular Momentum Experiment	
DataStudio Lite Software	

NEW **Downloads Available**

Each experiment manual and the DataStudio files may be downloaded free at **www.pasco.com**

Type the experiment number EX-XXXX into the search box to find the download information.

Order Information:

Conservation of Energy II **EX-9961**

Required:

PASPORT Interface ..... p. 10-23

Universal Gravitational Constant

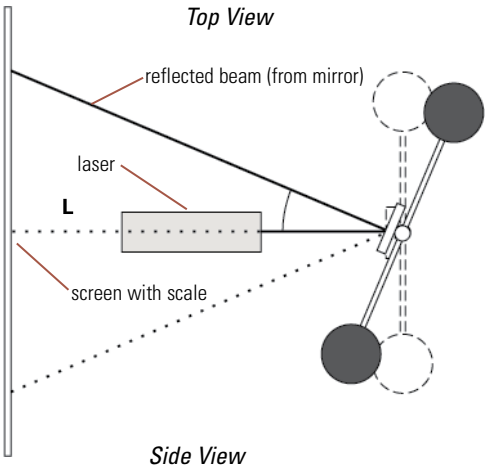
EX-9908

Concepts:

- Measure the Universal Gravitational Constant
- Recreate Cavendish's Historical Experiment

In the Universal Gravitational Constant Experiment, students measure the attractive force between two sets of tungsten spheres. Using this force, the mass of each sphere, and the separation of the spheres, the universal gravitational constant can be determined.

The attraction between a pair of small tungsten spheres and a pair of larger tungsten 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, thus the laser reflection on the screen or wall is displaced. The displacement of the laser reflection is measured and an "optical lever" calculation is used to find "G".



Masses are now tungsten rather than lead.

The large tungsten balls are rotated to produce a torque on the beryllium torsion band. The angular displacement of the band causes the reflected laser beam to be displaced, which is used to calculate "G".

Experiment Includes:

Gravitational Torsion Balance	AP-8215
X-Y Adjustable Diode Laser	OS-8526A
45 cm Steel Rod	ME-8736
Large Table Clamp	ME-9472
Universal Gravitational Constant Experiment Manual	

NEW Downloads Available

Each experiment manual and the DataStudio files may be downloaded free at **www.pasco.com**

Type the experiment number EX-XXXX into the search box to find the download information.

PASCO Advantage

PASCO's Gravitational Torsion Balance features a rugged torsion band that rarely needs to be replaced. If the band fails it can be replaced using a screwdriver in less than 10 minutes. In addition, a "U"-shaped groove in the housing allows students to damp the oscillation of the small tungsten balls, reducing measurement time from hours to minutes. Finally, an equilibrium adjustment knob on the top of the unit allows the angle of the mirror to be easily adjusted.

Order Information:

Universal Gravitational Constant	**EX-9908**
Gravitational Ballistic Replacement Set	**AP-8219**

Archimedes' Principle

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.

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.

Experiment Includes:

Density Set	ME-8569
Overflow Can	SE-8568
Rod Base	ME-8735
45 cm Steel Rod	ME-8736
Physics String	SE-8050
Triple-Beam Balance	SE-8707
Stainless Steel Calipers	SF-8711
1000 ml Beaker	SE-7288
100 ml Beaker	SE-7287
50 ml Graduated Cylinder	SE-7289
Archimedes' Principle Experiment Manual	

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.

PASCO Advantage

The provided objects have related volumes, masses and densities to demonstrate that only the volume of water displaced affects the buoyant force.

NEW **Downloads Available**

Each experiment manual and the DataStudio files may be downloaded free at **www.pasco.com**

Type the experiment number EX-XXXX into the search box to find the download information.

Order Information:

Archimedes' Principle (Balance) **EX-9909**

Materials Stress Strain

EX-9927 *ScienceWorkshop*
EX-9928 PASPORT

Concepts:

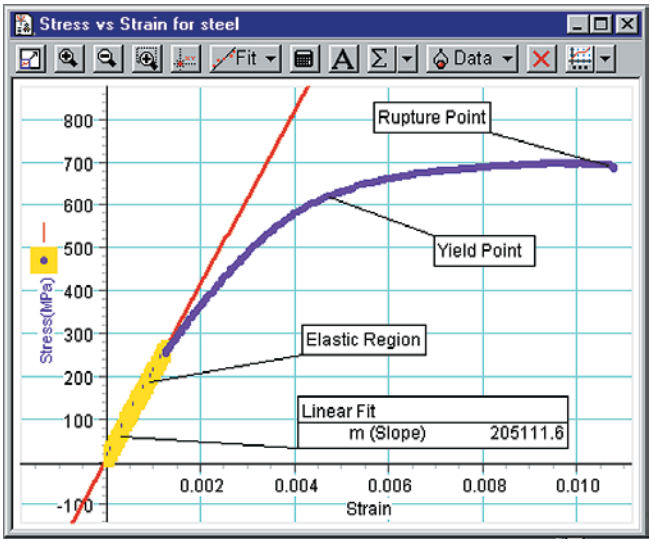
- Stress
- Strain
- Young's Modulus
- Yield Point

Method

In this experiment, students test a variety of materials by stretching them until failure under the tensile load. The sample is placed in the holder and firmly held on both ends. By turning the hand crank, the sample is stretched in one dimension. During the stretching, the Force Sensor measures the applied force through the 5 to 1 lever arm. This allows the maximum allowable force in the experiment to be 250 N. Simultaneously, the Rotary Motion Sensor measures the stretch of the sample real-time. Using DataStudio® software, the stress and strain can be calculated and graphed versus one another. The slope of the stress-strain graph in the elastic region is known as Young's Modulus. The transition between elastic and plastic deformation is known as the Yield Point; this point can be easily determined from the DataStudio graph.

PASCO Advantage

Students experience the tensile failure of various materials and collect critical measurements real-time with PASCO probeware. DataStudio graphs and calculations are created to extend student understanding of materials science. The compact size of the Stress-Strain Apparatus makes it ideal for any laboratory or classroom setting.



Young's Modulus for steel is determined using a linear curve fit on the elastic portion of the curve.

Experiment Includes:	EX-9927 *ScienceWorkshop*	EX-9928 PASPORT
Stress-Strain Apparatus	AP-8214	AP-8214
Force Sensor	CI-6746	PS-2104
Rotary Motion Sensor	CI-6538	PS-2120
Stainless Steel Calipers	SF-8711	SF-8711
Materials Stress-Strain Experiment Manual		
DataStudio File for Materials Stress-Strain Experiment		
DataStudio Lite Software		

NEW **Downloads Available**

Each experiment manual and the DataStudio files may be downloaded free at **www.pasco.com**
Type the experiment number EX-XXXX into the search box to find the download information.

Order Information:

Materials Stress-Strain (*ScienceWorkshop*) **EX-9927**
Materials Stress-Strain (PASPORT) **EX-9928**
Required for use with ScienceWorkshop:
ScienceWorkshop 500 or *750* Interface ..... p. 68-72
DataStudio Software ..... p. 86-89
Required for use with PASPORT:
PASPORT Interface ..... p. 10-23
DataStudio Software ..... p. 86-89

Rotational Inertia

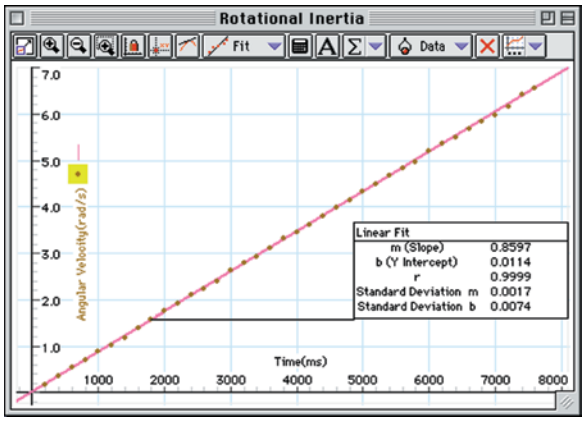
EX-9936 *ScienceWorkshop*
EX-9942 PASPORT

Concepts:

- Rotational inertia of a ring and a 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 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 versus 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.



The rotational inertia of the ring and disk is calculated from the angular acceleration obtained from the slope of this angular velocity versus time graph.

A known torque is applied to the ring and disk by the weight hanging over the pulley. The rotational inertia of the ring and disk are determined from the resulting angular acceleration. The procedure is repeated for the disk alone.

PASCO Advantage

Friction can be neglected in this compact setup. The Rotary Motion Sensor is a versatile tool which can be used in a variety of other experiments.

Experiment Includes:	EX-9936 *ScienceWorkshop*	EX-9942 PASPORT
Large Rod Base	ME-8735	ME-8735
90 cm Steel Rod	ME-8738	ME-8738
Mini-Rotational Accessory	CI-6691	CI-6691
Drilled Mass & Hanger Set (5 g resolution)	ME-9348	ME-9348
Rotary Motion Sensor	CI-6538	PS-2120
Rotational Inertia Experiment Manual		
DataStudio File for Sliding Friction Experiment		
DataStudio Lite Software		

NEW Downloads Available

Each experiment manual and the DataStudio files may be downloaded free at **www.pasco.com**
Type the experiment number EX-XXXX into the search box to find the download information.

Order Information:

Rotational Inertia (*ScienceWorkshop*) **EX-9936**
Rotational Inertia (PASPORT) **EX-9942**
Required for use with ScienceWorkshop:
ScienceWorkshop 500, 700 or *750* Interface ..... p. 68-72
DataStudio Software ..... p. 86-89
Required for use with PASPORT:
PASPORT Interface ..... p. 10-23
DataStudio Software ..... p. 86-89

Conservation of Angular Momentum

EX-9960 PASPORT or Xplorer GLX Stand-alone

Concepts:

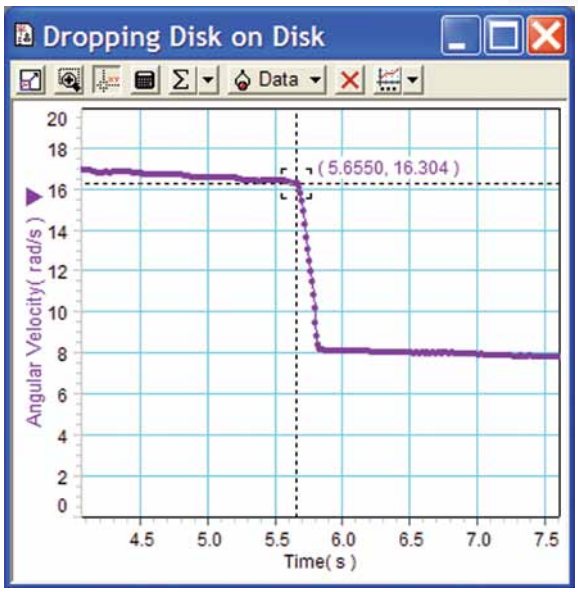
- Conservation of Angular Momentum During Collisions
- Easy Determination of Before and After Points
- Calculation of Energy Lost During Collision

The study of conservation of angular momentum during collisions is easy and fast using this system based on the Rotary Motion Sensor. The angular velocity of the spinning disk is graphed in real-time as a non-rotating ring is dropped onto it.

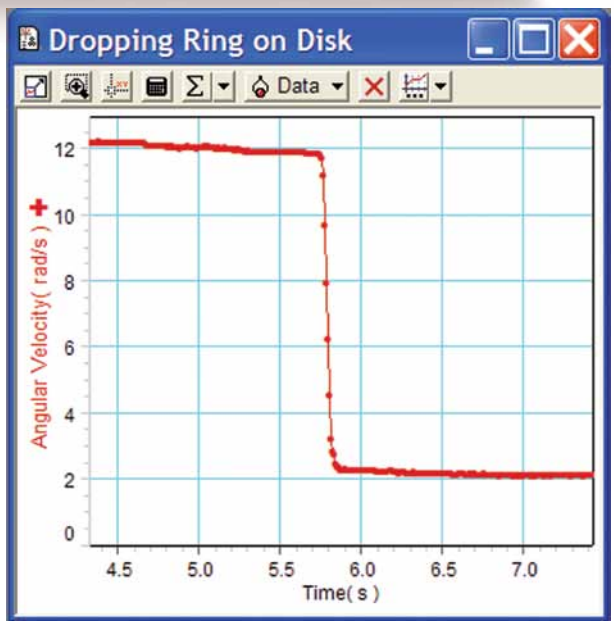
It is easy to measure the rotational speeds just before and after the collision since the entire collision is visible in the graph.

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.



A disk is dropped onto a rotating disk. Since the disks are identical, the angular velocity decreases by half.



As a non-rotating ring is dropped onto a rotating disk, the angular velocity decreases to about 1/6th of its initial value since the ring has a large rotational inertia compared to the disk.

Experiment Includes:

Rotary Motion Sensor	PS-2120
Rotational Accessory	CI-6691
Balance	SE-8723
Calipers	SF-8711
Large Rod Stand	ME-8735
45 cm Long Steel Rod	ME-8736

Conservation of Angular Momentum Experiment Manual
Xplorer GLX Files for Conservation of Angular Momentum Experiment
DataStudio Lite Software

NEW **Downloads Available**

Each experiment manual and the DataStudio files may be downloaded free at **www.pasco.com**

Type the experiment number EX-XXXX into the search box to find the download information.

Order Information:

Conservation of Angular Momentum **EX-9960**

Required:

PASPORT Interface ..... p. 10-23

Large Amplitude Pendulum

EX-9905 *ScienceWorkshop*

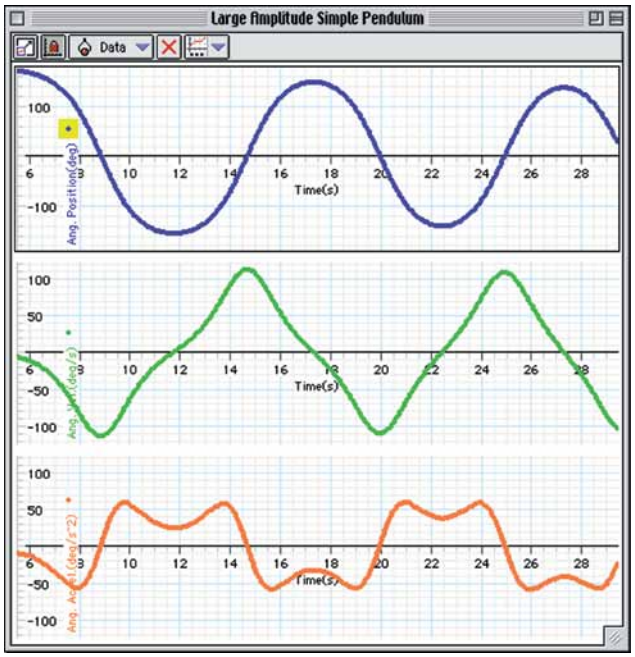
Concepts:

- Low Amplitude Approximation for the Pendulum Period
- Large Amplitude Period
- Shape of Displacement, Velocity and Acceleration Curves for Large Amplitude

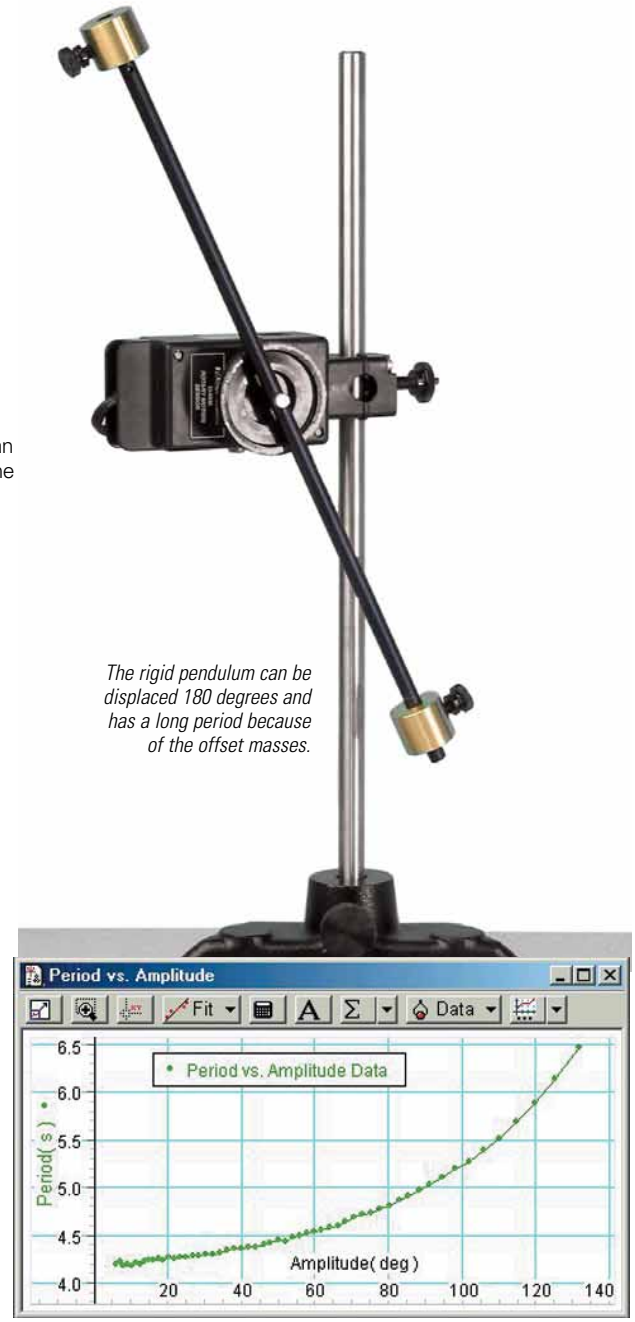
This experiment explores the dependence of the period of a simple pendulum on the amplitude of the oscillation. Also, the displacement, velocity and acceleration for large amplitude are plotted versus time to show the difference from the sinusoidal motion of low amplitude oscillations.

A rigid pendulum consists of a 35 cm long lightweight (28 g) aluminum tube with a 75 g mass on each end. The center of the tube is mounted on a Rotary Motion Sensor. One of the masses is slightly closer to the center than the other mass, so the pendulum will oscillate slowly. Students will have time to view the motion of the pendulum while also watching the real-time graph of displacement, velocity and acceleration versus time.

The period is measured as a function of the amplitude of the pendulum and compared to theory.



Graphs of angular displacement, velocity and acceleration versus time are displayed for a pendulum oscillating with large amplitude.



The rigid pendulum can be displaced 180 degrees and has a long period because of the offset masses.

The pendulum period is plotted versus amplitude.

Experiment Includes:

Large Rod Base	ME-8735
45 cm Steel Rod	ME-8736
Pendulum Accessory	003-05971
Rotary Motion Sensor	CI-6538
Large Amplitude Pendulum Experiment Manual	
DataStudio File for Large Amplitude Pendulum Experiment	

PASCO Advantage

DataStudio has a period function which can be plotted versus the amplitude in real-time as the pendulum's oscillation damps out. The pendulum is initially displaced almost 180 degrees and then, as the amplitude decreases because of friction, the period is automatically recorded as a function of amplitude.

NEW Downloads Available

Each experiment manual and the DataStudio files may be downloaded free at **www.pasco.com**

Type the experiment number EX-XXXX into the search box to find the download information.

Order Information:

Large Amplitude Pendulum	**EX-9905**
Required:	
ScienceWorkshop 500 or *750* Interface	p. 68-72
DataStudio Software	p. 86-89

Variable-g Pendulum

EX-9904 *ScienceWorkshop*

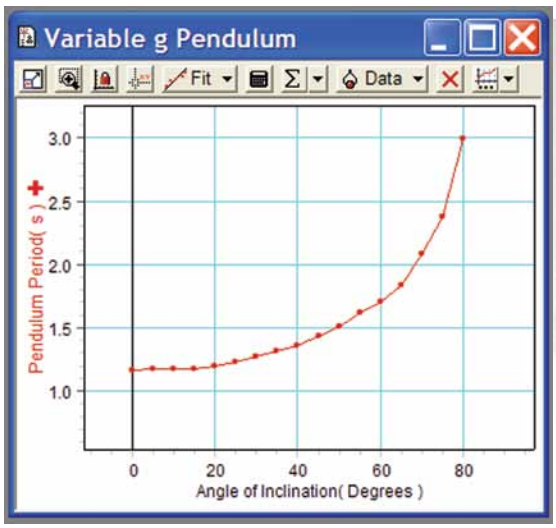
Concepts:

- Period of a Simple Pendulum
- Effect of Decreasing "g" on the Pendulum Period
- Large Amplitude Period
- Shape of Displacement, Velocity and Acceleration Curves for Large Amplitude

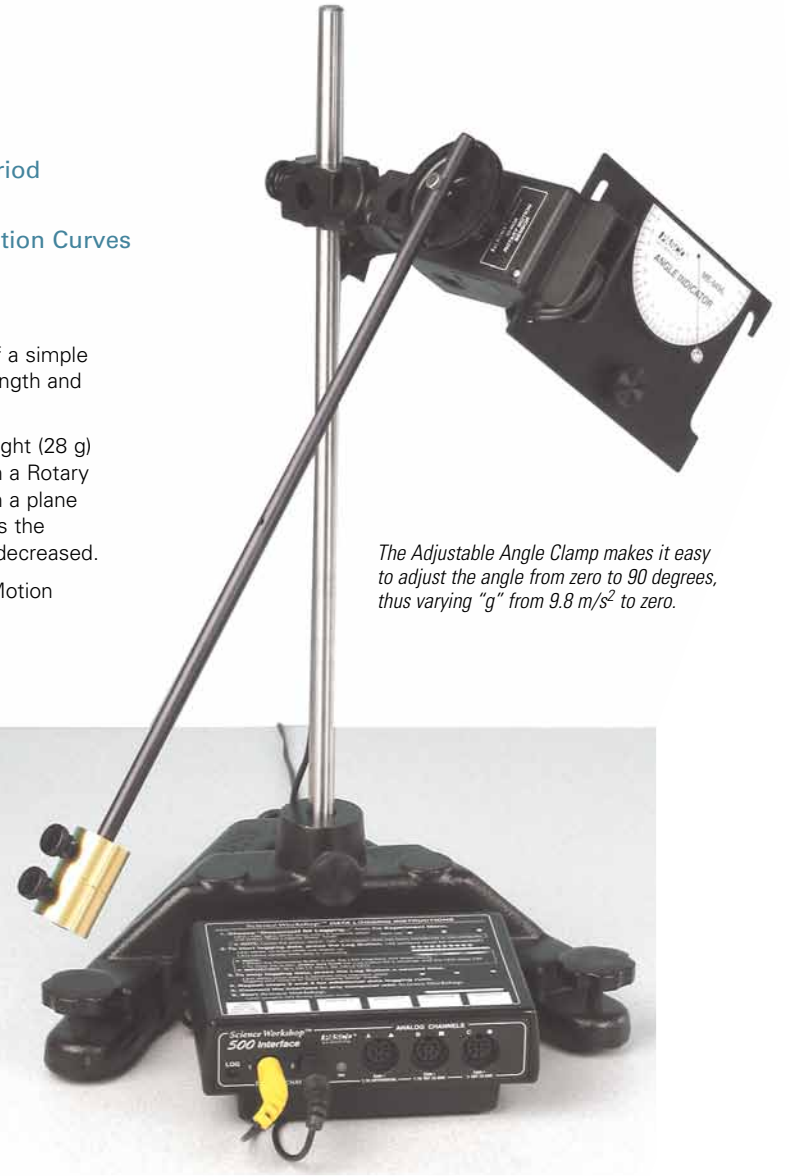
This experiment explores the dependence of the period of a simple pendulum on the acceleration due to gravity and on the length and amplitude of the pendulum.

A simple rigid pendulum consists of a 35 cm long lightweight (28 g) aluminum tube with a 150 g mass at the end, mounted on a Rotary Motion Sensor. The pendulum is constrained to oscillate in a plane tilted at an angle from the vertical. This effectively reduces the acceleration due to gravity because the restoring force is decreased.

The period of the pendulum is measured using a Rotary Motion Sensor and the period function in DataStudio.



The period of the Variable-g Pendulum is plotted as a function of the angle of inclination to show the dependence of the period on g.



The Adjustable Angle Clamp makes it easy to adjust the angle from zero to 90 degrees, thus varying "g" from 9.8 m/s^2 to zero.

PASCO Advantage

The rigid pendulum can be assumed to be a simple pendulum: The actual period is approximately 99% of the period of a simple pendulum of the same length.

Experiment Includes:

Large Rod Base	ME-8735
45 cm Steel Rod	ME-8736
Variable-g Pendulum Accessory	ME-8745
Pendulum Accessory	003-05971
Rotary Motion Sensor	CI-6538
Variable-g Pendulum Experiment Manual	
DataStudio Files for Variable-g Pendulum Experiment	
DataStudio Lite Software	

NEW Downloads Available

Each experiment manual and the DataStudio files may be downloaded free at **www.pasco.com**

Type the experiment number EX-XXXX into the search box to find the download information.

Order Information:

Variable-g Pendulum Experiment Kit **EX-9904**

Required for use with ScienceWorkshop:

ScienceWorkshop 500, 700 or *750* Interface ..... p. 68-72

DataStudio Software ..... p. 86-89

Torsional Pendulum

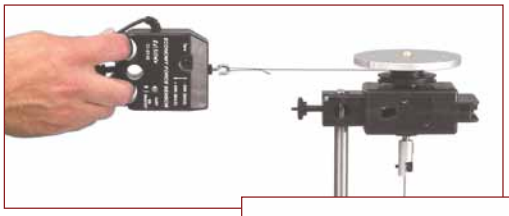
EX-9903 *ScienceWorkshop*
EX-9943 PASPORT

Concepts:

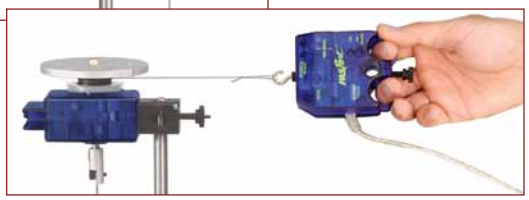
- Period of a Torsional Pendulum
- Rotational Inertias of a Disk, Ring and Point Masses
- Torque
- Torsional Spring Constant

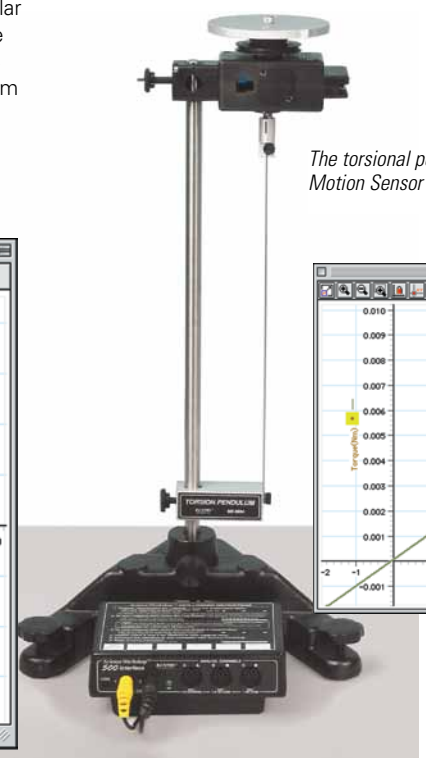
The period of a Torsional Pendulum is measured and compared to the theoretical value. The torsional pendulum consists of a torsion wire attached to a Rotary Motion Sensor with an object (a disk, ring or a rod with point masses) mounted on top of it. The period of oscillation is measured from a plot of 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.

The dependence of the period on the torsional constant and the rotational inertia is explored by using different diameter wires and different shaped objects.

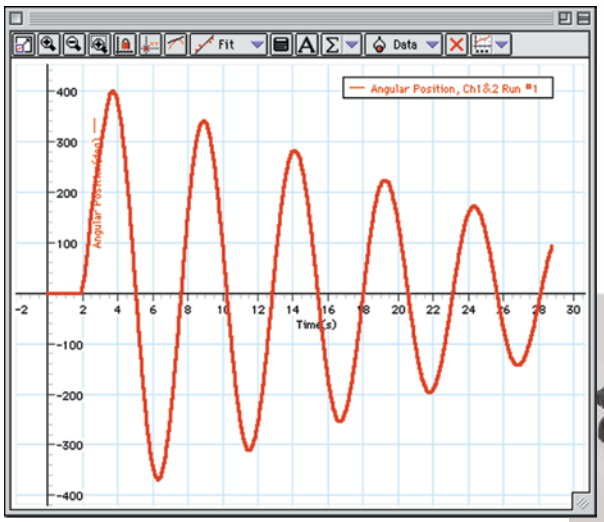


To determine the torsional spring constant, a torque is applied by pulling with a Force Sensor.

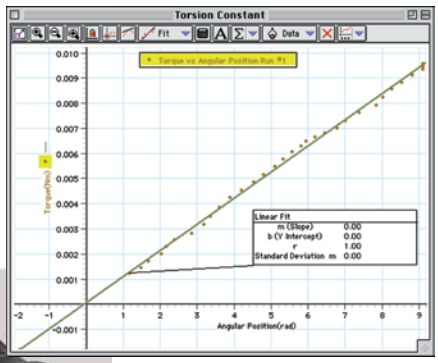




The torsional pendulum uses a Rotary Motion Sensor to record the oscillations.



The period of the torsional pendulum is determined from a plot of angular displacement versus time.



The torsional spring constant is determined from a plot of torque versus angular displacement.

PASCO Advantage

To determine the torsional spring constant, the force versus angular displacement graph is quickly and easily obtained by pulling with a Force Sensor on a string wrapped around the Rotary Motion Sensor pulley.

Experiment Includes:	EX-9903 *ScienceWorkshop*	EX-9943 PASPORT
Torsion Pendulum Accessory	ME-6694	ME-6694
Large Rod Base	ME-8735	ME-8735
45 cm Steel Rod	ME-8736	ME-8736
Mini-Rotational Accessory	CI-6691	CI-6691
Rotary Motion Sensor	CI-6538	PS-2120
Force Sensor	CI-6537	PS-2104
Torsional Pendulum Experiment Manual		
DataStudio File for Sliding Friction Experiment		
DataStudio Lite Software		

NEW **Downloads Available**

Each experiment manual and the DataStudio files may be downloaded free at
www.pasco.com
Type the experiment number EX-XXXX into the search box to find the download information.

Order Information:

Torsional Pendulum (*ScienceWorkshop*) **EX-9903**
Torsional Pendulum (PASPORT) **EX-9943**
Required for use with ScienceWorkshop:
ScienceWorkshop 500, 700 or *750* Interface ..... p. 68-72
DataStudio Software ..... p. 86-89
Required for use with PASPORT:
PASPORT Interface ..... p. 10-23
DataStudio Software ..... p. 86-89

Driven Damped Harmonic Oscillator

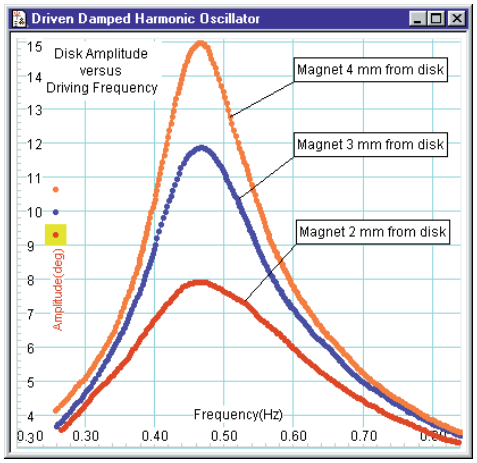
EX-9906 *ScienceWorkshop*
EX-9970 PASPORT

Concepts:

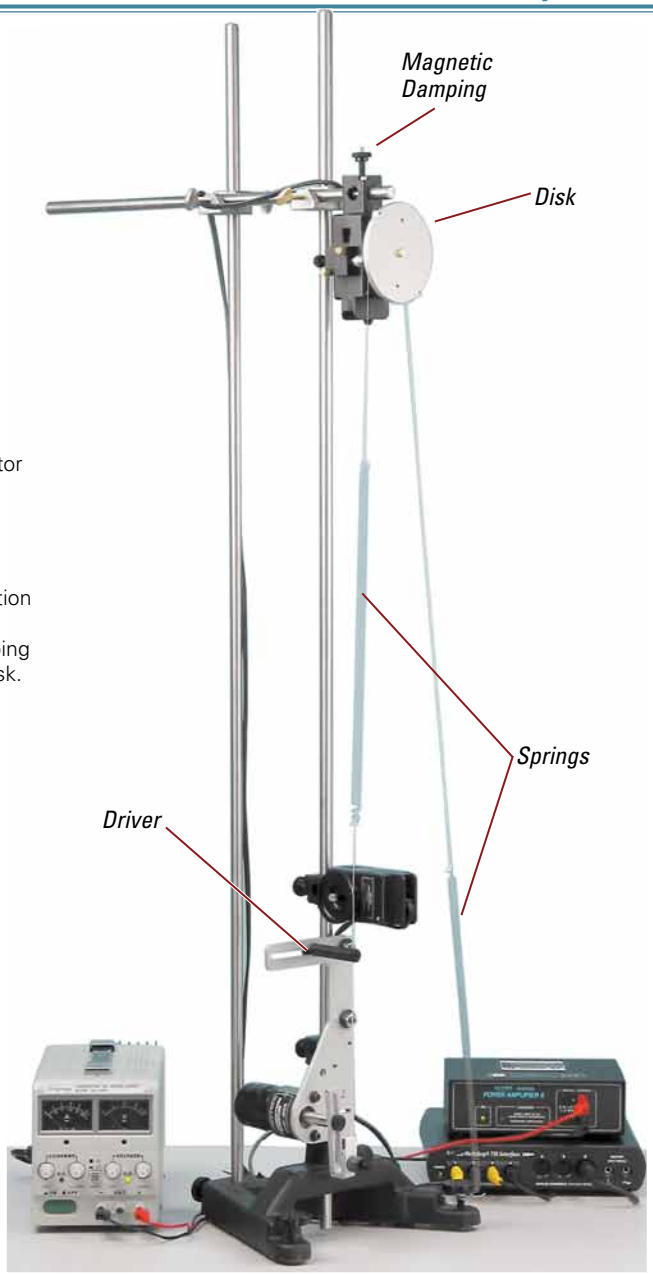
- Resonance Curves for an Oscillator: Amplitude vs. Frequency
- Resonant Frequency
- Period of a Pendulum
- Effect of Magnetic Damping on Shape of Resonance Curve
- Phase Difference Between Oscillator and Driver at Low, Resonant and High Frequencies

In this experiment, the resonance of a driven damped harmonic oscillator is examined by plotting the oscillation amplitude versus 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 versus the driving frequency for different amounts of magnetic damping. Increased damping is provided by moving an adjustable magnet closer to the aluminum disk.



This graph shows the resonance curves (amplitude vs. frequency) for three different settings of magnetic damping.



The magnetically damped oscillator is driven by a sinusoidal mechanical driver.

PASCO Advantage

The combination of DataStudio and the *750* Interface has the power to sweep through the driver frequencies and the capability to plot the amplitude versus the driver frequency in real-time.

Experiment Includes:	EX-9906 *ScienceWorkshop*	EX-9970 PASPORT
Chaos/Driven Harmonic Accessory	CI-6689A	CI-6689A
Mechanical Oscillator/Driver	ME-8750	ME-8750
Large Rod Base	ME-8735	ME-8735
120 cm Steel Rod (2)	ME-8741	ME-8741
45 cm Steel Rod	ME-8736	ME-8736
Multi-Clamps (2)	SE-9442	SE-9442
Rotary Motion Sensor (2)	CI-6538	PS-2120
Braided Physics String	SE-8050	SE-8050
DC Power Supply	------	PI-9877
Power Supply (18V DC, 5A)	SE-9720A	------
Power Amplifier II	CI-6552A	------
Banana Plug Cords – Red (5 pack)	SE-9750	SE-9750
Driven Damped Harmonic Oscillations Experiment Manual		
DataStudio Files for Driven Damped Harmonic Oscillations Experiment		
DataStudio Lite Software		

NEW **Downloads Available**

Each experiment manual and the DataStudio files may be downloaded free at
www.pasco.com
Type the experiment number EX-XXXX into the search box to find the download information.

Order Information:

Driven Damped Harmonic Oscillator (*ScienceWorkshop*) **EX-9906**
***NEW* Driven Damped Harmonic Oscillator (PASPORT)** **EX-9970**
Required:
ScienceWorkshop 750 Interface ..... p. 68-72
DataStudio Software ..... p. 86-89
Required for use with PASPORT:
PASPORT Interface ..... p. 10-23
DataStudio Software ..... p. 86-89

Chaos

EX-9907 *ScienceWorkshop*

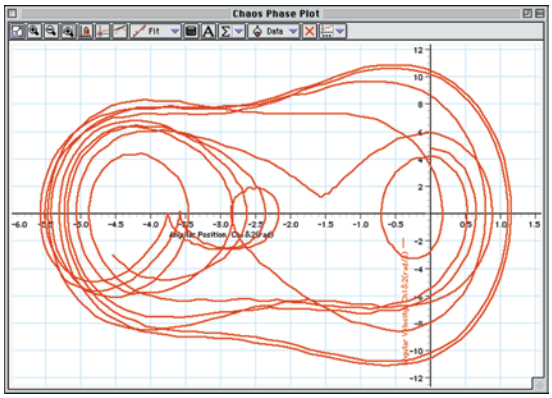
Concepts:

- 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 versus the displacement angle of the oscillation.

The Poincare plot is also graphed in real-time, 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.



This phase plot (angular velocity versus displacement angle) shows the first few cycles of chaotic movement of the oscillator.

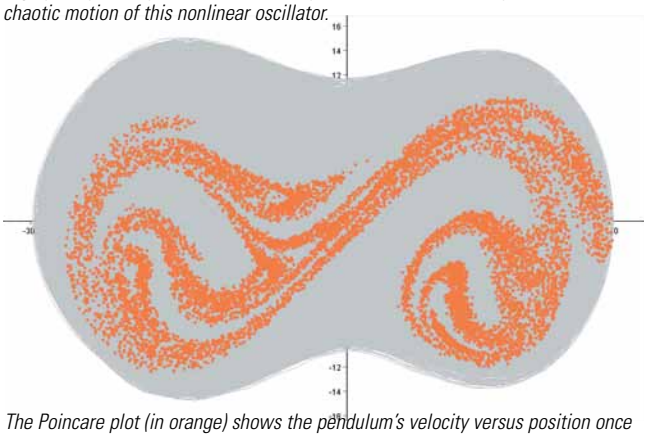
PASCO Advantage

DataStudio® 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 actual motion of the oscillator.

Experiment Includes:

Large Rod Base	ME-8735
120 cm Steel Rod (2)	ME-8741
45 cm Steel Rod	ME-8736
Multi Clamp (2)	SE-9442
Chaos/Driven Harmonic Accessory	CI-6689A
Mechanical Oscillator/Driver	ME-8750
Power Supply (18 V DC, 5A)	SE-9720
Rotary Motion Sensor	CI-6538
Photogate Head	ME-9498A
Basic Digital Multimeter	SE-9786A
Banana Plug Cord-Red (5 Pack)	SE-9750
Chaos Experiment Manual	
DataStudio File for Chaos Experiment	

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 versus position once per revolution of the driver. The grey background is the phase plot.

NEW Downloads Available

Each experiment manual and the DataStudio files may be downloaded free at **www.pasco.com**

Type the experiment number EX-XXXX into the search box to find the download information.

Order Information:

Chaos **EX-9907**

Required:

ScienceWorkshop 750 Interface ..... p. 68-72

DataStudio Software ..... p. 86-89

Specific Heat

EX-9977 *ScienceWorkshop*

Concepts:

- Thermal Energy
- Equilibrium Temperature
- Specific Heat

Students learn 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.

Experiment Includes:

Temperature Sensor	CI-6605
Calorimetry Cups	TD-8825A
Specific Heat Set	SE-6849
Balance	SE-8723
Hot Plate	SE-8830
Graduated Cylinder 100ml	SE-7289
Beaker 1000 ml	SE-7288
Braided Physics String	SE-8050
Specific Heat Experiment Manual	
DataStudio File for Specific Heat Experiment	
DataStudio Lite Software	

Downloads Available

Each experiment manual and the DataStudio files may be downloaded free at **www.pasco.com**

Type the experiment number EX-XXXX into the search box to find the download information.

Order Information:

Specific Heat **EX-9977**

Required:

ScienceWorkshop 500 or *750* Interface ..... p. 68-73

DataStudio Software ..... p. 86-89

Electrical Equivalent of Heat

EX-9962 PASPORT

EX-9963 Xplorer GLX

Concepts:

- Hand-Cranked Generator provides tactile experience
- Power is plotted as work is done
- See the temperature rise

Nothing reinforces the relationship between mechanical work and heat better than hand cranking a generator to produce electricity and electrically heating water.

With the PASCO Hand Crank Generator, Calorimeter and the Xplorer GLX to measure temperature and voltage, turns a qualitative demonstration into a quantitative experiment.

The student cranks the generator by hand, causing a current to flow through the heating resistor. The dissipated heat warms the water in the calorimetry cup.

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 top graph displays the power output from the generator and the bottom graph the increase in temperature. The amount of electrical energy used to heat to the water is determined by finding the area under the power versus time curve.

Experiment Includes:	EX-9962 PASPORT	EX-9963 Xplorer GLX
Energy Transfer-Calorimeter	ET-8499	ET-8499
Hand Crank Generator	EM-8090	EM-8090
Voltage/Current Sensor	PS-2115	PS-2115
Fast-Response Temperature Probe	PS-2135 *(Incl. with GLX)*	*Included with Xplorer GLX*
Temperature Sensor	PS-2125 *(Not required for GLX)*	*Not required for Xplorer GLX*
Mass Scale	SE-8707	SE-8707
Electrical Equivalent of Heat Experiment Manual		
DataStudio File for Electrical Equivalent of Heat Experiment		
DataStudio Lite Software		

Downloads Available

Each experiment manual and the DataStudio files may be downloaded free at **www.pasco.com**

Type the experiment number EX-XXXX into the search box to find the download information.

Order Information:

Electrical Equivalent of Heat (PASPORT) **EX-9962**

Electrical Equivalent of Heat (Xplorer GLX) **EX-9963**

Required:

PASPORT Interface/Xplorer GLX ..... p. 10-23

DataStudio Software ..... p. 86-89

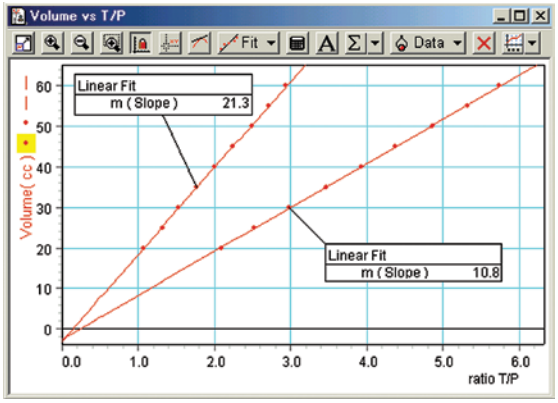
Ideal Gas Law

EX-9950 *ScienceWorkshop*
EX-9954 PASPORT

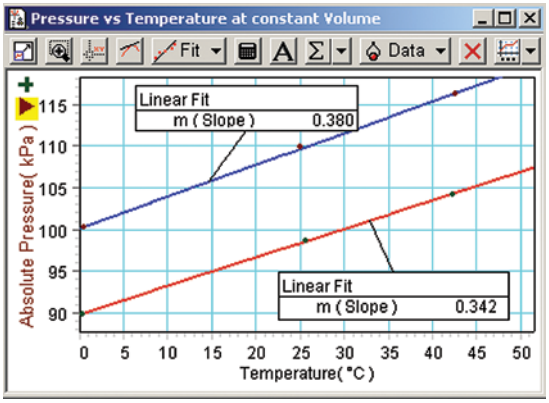
Concepts:

- Ideal Gas Law
- Boyle's Law
- Gay-Lussac's Law

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 right) the slope of the Volume vs. $\frac{T}{P}$ graph equals nR.



For the Absolute Zero Apparatus (shown at right) which has constant volume, the pressure versus temperature graphs have different slopes corresponding to different number of moles in the container.

Experiment Includes:	EX-9950 *ScienceWorkshop*	EX-9954 PASPORT
Ideal Gas Law Syringe	TD-8596	TD-8596
Absolute Zero Apparatus	TD-8595	TD-8595
Plastic Containers (3L, 2 pack)	740-183	740-183
Pressure Sensor	CI-6532A	not needed
Thermistor Temperature Sensor	CI-6527A	not needed
Pressure/Temperature Sensor	not needed	PS-2146
Ideal Gas Law Experiment Manual		
DataStudio File for Ideal Gas Law		
DataStudio Lite Software		

PASCO Advantage

The Ideal Gas Syringe and Absolute Zero Sphere have a thermistor with small mass that responds quickly to temperature changes.

NEW Downloads Available

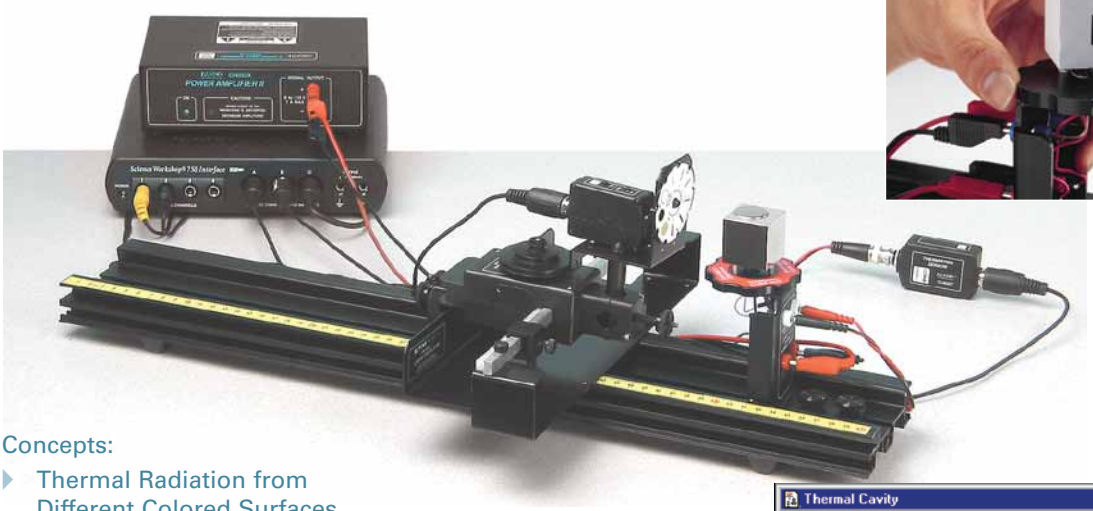
Each experiment manual and the DataStudio files may be downloaded free at **www.pasco.com**
Type the experiment number EX-XXXX into the search box to find the download information.

Order Information:

Ideal Gas Law (*ScienceWorkshop*) **EX-9950**
Ideal Gas Law (PASPORT) **EX-9954**
Required for use with ScienceWorkshop:
ScienceWorkshop 500, 700 or *750* Interface ..... p. 68-72
Required for use with PASPORT:
USB Link (2), Xplorer (2), PowerLink, or Xplorer GLX ..... p. 10-23

Cavity Radiation

EX-9912 *ScienceWorkshop*



The surface of the cube is scanned with two different Light Sensors (visible and infrared).

Concepts:

- Thermal Radiation from Different Colored Surfaces
- Cavity Radiation

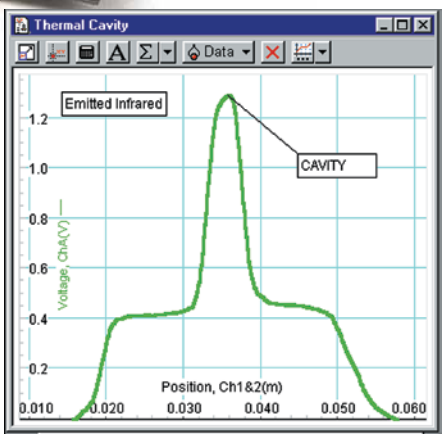
The amounts of thermal radiation from different colored surfaces and a cavity, all at the same temperature, are compared.

An aluminum cube has sides that are black, white, polished aluminum and matte aluminum with a hole. The cube is heated to approximately 90°C and an Infrared Light Sensor is moved across the face with the hole in it to show that the hole emits more infrared radiation than the surrounding surface. A Rotary Motion Sensor on a Linear Translator keeps track of the light sensor position and the light intensity versus position is plotted. The scan in the visible spectrum is made with a Light Sensor to confirm that the hole is darker than the surrounding surface.

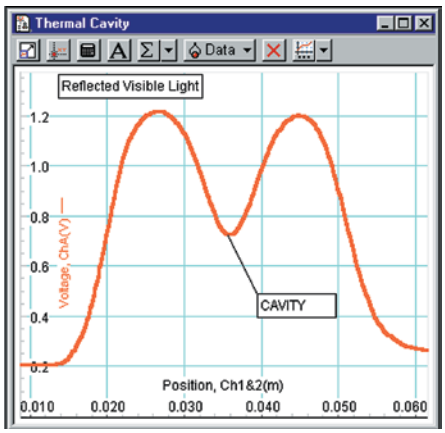
Also, the intensity of radiation from the different colored surfaces is compared.

PASCO Advantage

The temperature of the cavity is controlled by the *750* Interface and measured using a Thermistor Temperature Sensor, which reads in degrees rather than resistance, eliminating confusion about the resistance decreasing as the temperature increases. The temperature is used to calculate the theoretical wavelength of maximum intensity emitted by the cavity.



In the infrared part of the spectrum, the hot cavity is surprisingly brighter than the surrounding matte aluminum surface.



In the visible part of the spectrum, the cavity is darker than its surroundings, as expected.

Experiment Includes:

Thermal Cavity	TD-8580
Banana Plug Cord-Red (5 Pack)	SE-9750
60 cm Optics Bench	OS-8541
Linear Translator	OS-8535
Aperture Bracket	OS-8534
Light Sensor	CI-6504A
Infrared Sensor	CI-6628
Rotary Motion Sensor	CI-6538
Thermistor Temperature Sensor	CI-6527A
Power Amplifier II	CI-6552A
Cavity Radiation Experiment Manual	
DataStudio File for Cavity Radiation Experiment	

NEW Downloads Available

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Type the experiment number EX-XXXX into the search box to find the download information.

Order Information:

Cavity Radiation **EX-9912**

Required:

ScienceWorkshop 750 Interface ..... p. 68-72

DataStudio Software ..... p. 86-89

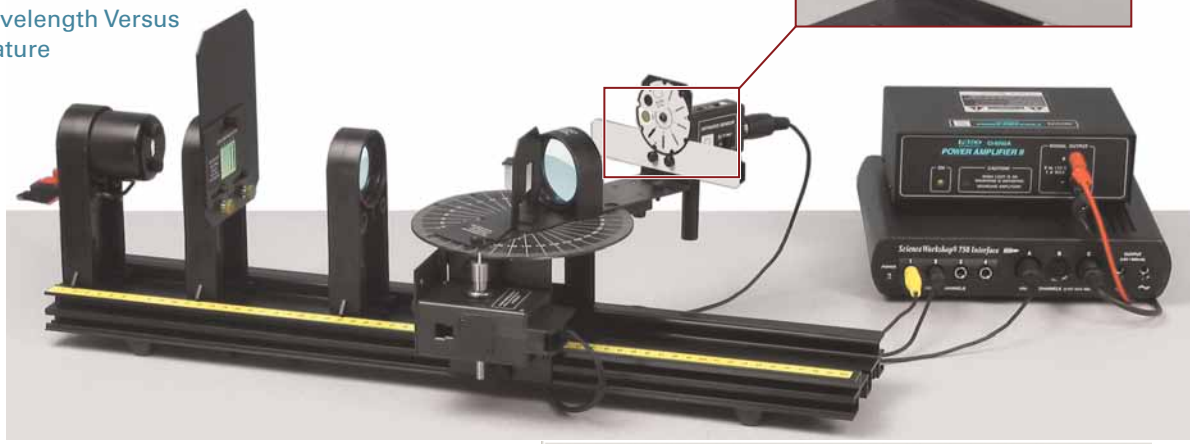
Blackbody Radiation

EX-9920 *ScienceWorkshop*
EX-9971 PASPORT

Concepts:

- Blackbody Spectrum
- Peak Wavelength Versus Temperature

The continuous blackbody spectrum is scanned using a prism spectrophotometer.

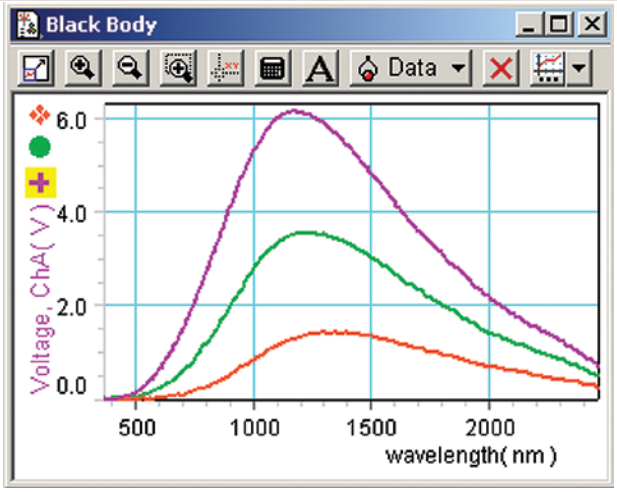


The classic blackbody spectrum of light intensity versus wavelength is obtained for a light bulb and the shift in the peak wavelength is demonstrated for different bulb temperatures.

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 the entire spectrum from 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: Results are qualitative and suitable for introductory classes only.



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 decreased.

PASCO Advantage

All the complex calculations for the angle-to-wavelength conversion are stored in the set-up file supplied for DataStudio.

Experiment Includes:	EX-9920 *ScienceWorkshop*	EX-9971 PASPORT
Spectrophotometer Accessory Kit	OS-8537	OS-8537
Optics Bench (60 cm)	OS-8541	OS-8541
Prism Spectrophotometer Kit	OS-8544	OS-8544
Aperture Bracket	OS-8534A	OS-8534A
Broad Spectrum Light Sensor	CI-6630	PS-2150
Rotary Motion Sensor	CI-6538	PS-2120
Voltage Sensor	CI-6503	———
Voltage/Current Sensor	———	PS-2115
Power Amplifier II	CI-6552A	———
DC Power Supply	———	PI-9877
Replacement Bulb (10 pack)	SE-8509	SE-8509
Banana Plug Cords – Black (5 pack)	SE-9751	SE-9751
Blackbody Radiation Experiment Manual		
DataStudio Files for Blackbody Radiation Experiment		
DataStudio Lite Software		

NEW **Downloads Available**

Each experiment manual and the DataStudio files may be downloaded free at **www.pasco.com**
Type the experiment number EX-XXXX into the search box to find the download information.

Order Information:

Blackbody Radiation (*ScienceWorkshop*) **EX-9920**
Blackbody Radiation (PASPORT) **EX-9971**
Required for use with ScienceWorkshop:
ScienceWorkshop 750 Interface ..... p. 68-72
DataStudio Software ..... p. 86-89
Required for use with PASPORT:
PASPORT Interface ..... p. 10-23
DataStudio Software ..... p. 86-89

Heat Engine Cycle

EX-9911 *ScienceWorkshop*
EX-9972 PASPORT

Concepts:

- Heat Engine Efficiency
- Isothermal Processes
- Isobaric Processes
- Ideal Gas Law

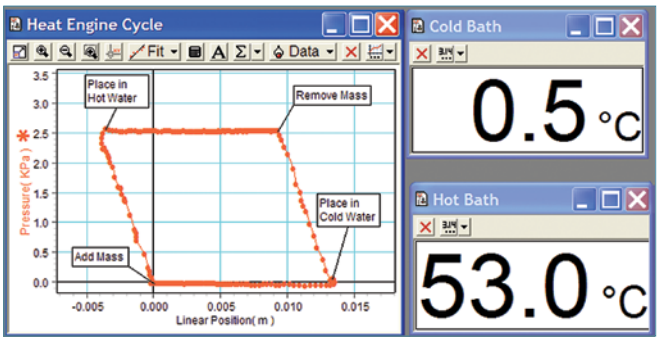
A P-V diagram is generated as a heat engine is taken through a cycle. From this diagram, the heat added to the gas and the work done by the engine are measured to determine the efficiency of the engine. This actual efficiency is compared to the theoretical maximum efficiency.

The heat engine consists of air inside a cylinder which 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 cycle is performed as follows:

1. With the can in the cold bath, the 200 g mass is placed on the platform.
2. The can is moved from the cold bath to the hot bath.
3. The 200 g mass is removed from the platform.
4. The can is moved from the hot bath to the cold bath.

The change in pressure is measured with a Low Pressure Sensor. The change in piston height is measured by the attached string over the Rotary Motion Sensor pulley. The change in volume is calculated by multiplying the change in piston height by the piston cross-sectional area.



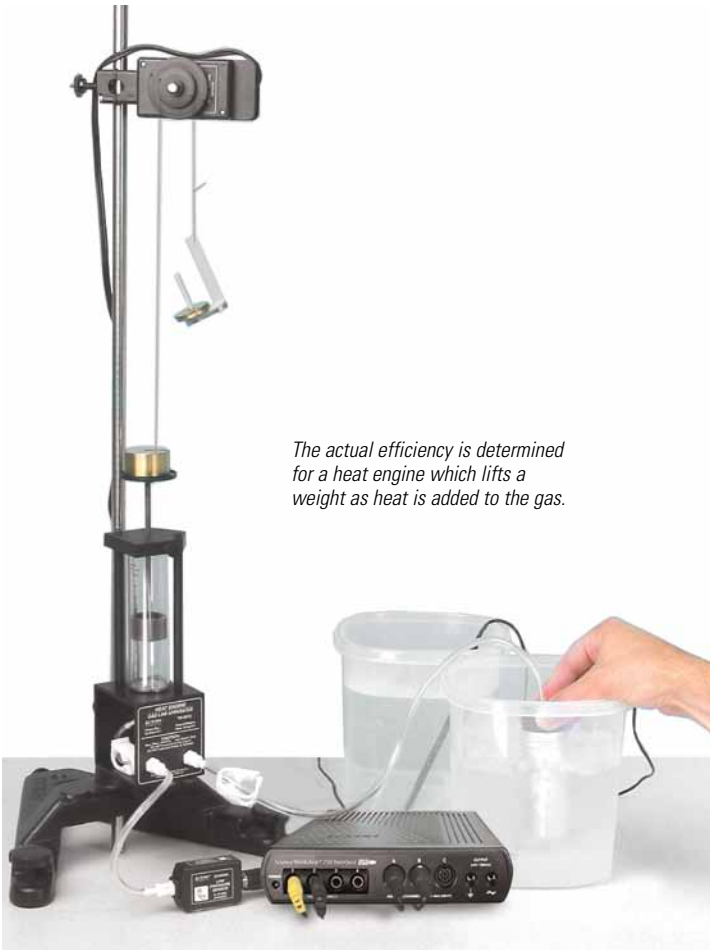
Graph of Pressure versus Piston Position

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.

NEW **Downloads Available**

Each experiment manual and the DataStudio files may be downloaded free at **www.pasco.com**
Type the experiment number EX-XXXX into the search box to find the download information.



The actual efficiency is determined for a heat engine which lifts a weight as heat is added to the gas.

Experiment Includes:	EX-9911 *ScienceWorkshop*	EX-9972 PASPORT
Heat Engine Apparatus	TD-8572	TD-8572
Large Rod Base	ME-8735	ME-8735
90 cm Steel Rod	ME-8738	ME-8738
Rotary Motion Sensor	CI-6538	PS-2120
Temperature Sensor (2)	CI-6605A	-------
Quad Temperature Sensor	-------	PS-2143
Low Pressure Sensor	CI-6534A	-------
Dual Pressure Sensor	-------	PS-2181
Plastic Containers (3.8 L, 2 pack)	ME-7559	ME-7559
Thread		
Mass Hanger (5 g)		
Drilled Mass (10 g)		
Drilled Mass (20 g)		
Slotted Mass (200 g)		
Heat Engine Cycle Experiment Manual		
DataStudio Files for Heat Engine Cycle Experiment		
DataStudio Lite Software		

Order Information:

Heat Engine Cycle (*ScienceWorkshop*) **EX-9911**
Heat Engine Cycle (PASPORT) **EX-9972**
Required for use with ScienceWorkshop:
ScienceWorkshop 500 or *750* Interface ..... p. 68-72
DataStudio Software ..... p. 86-89
Required for use with PASPORT:
PASPORT Interface ..... p. 10-23
DataStudio Software ..... p. 86-89

Ratio of Specific Heats

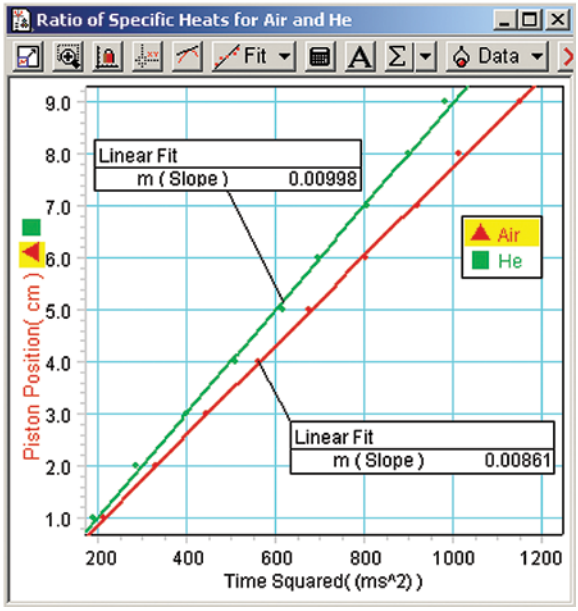
EX-9910 *ScienceWorkshop*
EX-9969 PASPORT

Concepts:

- C_p/C_V for a Gas
- Ruchhardt'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 Ruchhardt'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 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 Ruchhardt's method.

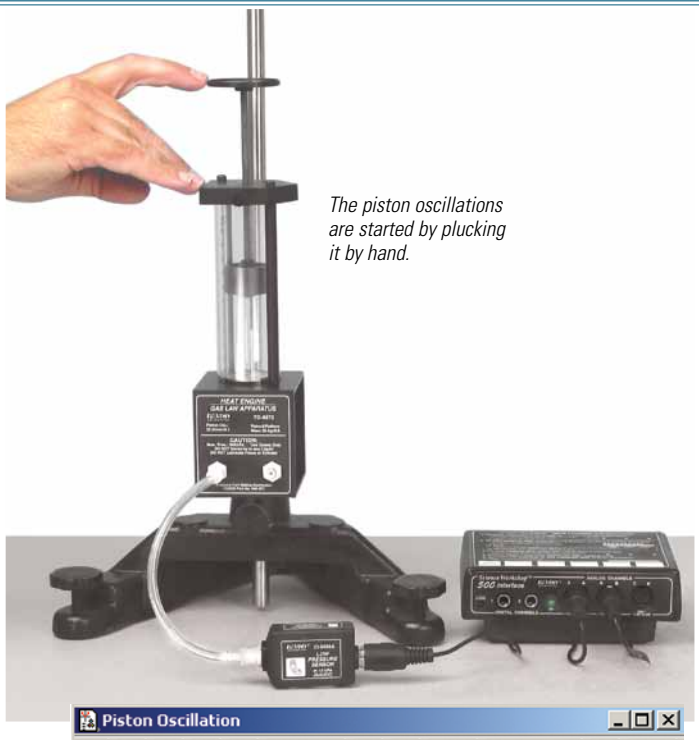


A plot of the position of piston versus the square of the period shows that the period increases as the gas volume increases. The slope of the line is related to the ratio of specific heats (C_p/C_V) and is different for the two gasses.

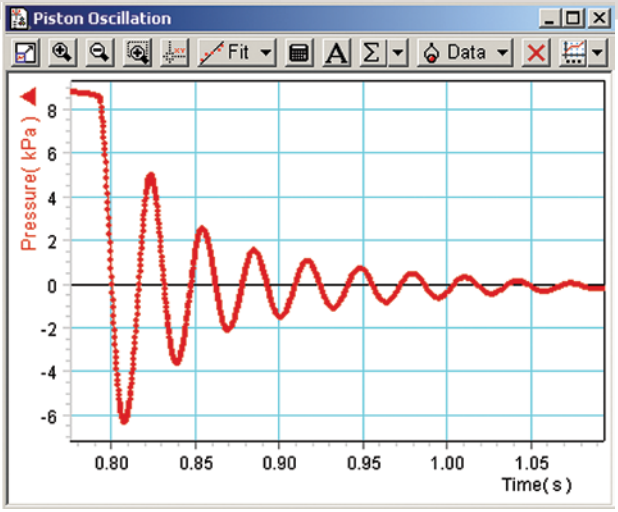
PASCO Advantage

Since the oscillations are plotted, it is easy to accurately measure the period of oscillation.

Experiment Includes:	EX-9910 *ScienceWorkshop*	EX-9969 PASPORT
Heat Engine/ Gas Law Apparatus	TD-8572	TD-8572
Large Rod Stand	ME-8735	ME-8735
45 cm Steel Rod	ME-8736	ME-8736
Low Pressure Sensor	CI-6534A	
Dual Pressure Sensor		PS-2181
Ratio of Specific Heats Experiment Manual		
DataStudio Files for Ratio of Specific Heats Experiment		
DataStudio Lite		



The piston oscillations are started by plucking it by hand.



The pressure oscillates after the piston is plucked by hand.

NEW **Downloads Available**

Each experiment manual and the DataStudio files may be downloaded free at **www.pasco.com**
Type the experiment number EX-XXXX into the search box to find the download information.

Order Information:

Ratio of Specific Heats (*ScienceWorkshop*) **EX-9910**
Ratio of Specific Heats (PASPORT) **EX-9969**

Required for use with ScienceWorkshop:
ScienceWorkshop 500 or *750* Interface ..... p. 68-72
DataStudio Software ..... p. 86-89
Required for use with PASPORT:
PASPORT Interface ..... p. 10-23
DataStudio Software ..... p. 86-89

Electrostatic Charge

EX-9978

NEW

Concepts:

- 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.

Experiment Includes:

Basic Electrometer	ES-9078
Charge Producers & Proof Plane	ES-9057C
Faraday Ice Pail and Shield	ES-9042A
Conductive Spheres	ES-9059C
Conductive Shapes	ES-9061
Electrostatics Voltage Source	ES-9077
Electrostatic Charge Experiment Manual	
DataStudio Files for Electrostatic Charge Experiment	

NEW **Downloads Available**

Each experiment manual and the DataStudio files may be downloaded free at **www.pasco.com**

Type the experiment number EX-XXXX into the search box to find the download information.

Order Information:

Electrostatic Charge **EX-9978**

Required for use with ScienceWorkshop:

ScienceWorkshop 500 or *750* Interface ..... p. 68-72

DataStudio Software ..... p. 86-89

Coulomb's Law

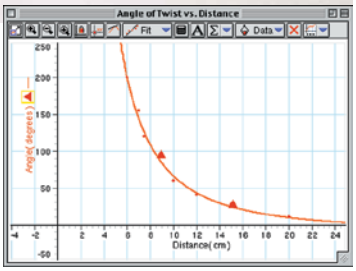
EX-9930

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: $k = 9.0 \times 10^9\ Nm^2/C^2$

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.

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.



Electrostatic force is directly proportional to the angle of twist.

Experiment Includes:

Coulomb's Law Apparatus	ES-9070
Kilovolt Power Supply	SF-9586
Basic Electrometer	ES-9078
Faraday Ice Pail	ES-9042A
Charge Producers and Proof Plane	ES-9057B
Coulomb's Law Experiment Manual	
DataStudio Lite Software	

NEW **Downloads Available**

Each experiment manual and the DataStudio files may be downloaded free at **www.pasco.com**

Type the experiment number EX-XXXX into the search box to find the download information.

Order Information:

Coulomb's Law **EX-9930**

Capacitance

EX-9985

NEW

Concepts:

- Capacitance
- Parallel Plate Capacitor
- Factors Effecting Capacitance

This lab explores the effect of varying the plate distance and insulating dielectric materials in a variable flat plate capacitor. Students also acquire data that allows the calculation of an experimentally derived value for the permittivity constant.

The Electrometer (ES-9078) used in this experiment makes it possible to measure the voltage across the capacitor plates without discharging the capacitor since it has an internal resistance of 10^{14} ohms.

Experiment Includes:

Basic Electrometer	ES-9078
Basic Variable Capacitor	ES-9079
Electrostatics Voltage Source	ES-9077
Capacitance Experiment Manual	
DataStudio Files for Capacitance Experiment	

NEW **Downloads Available**

Each experiment manual and the DataStudio files may be downloaded free at **www.pasco.com**

Type the experiment number EX-XXXX into the search box to find the download information.

Order Information:

Capacitance **EX-9985**

Required for use with ScienceWorkshop:

ScienceWorkshop 500 or *750* Interface ..... p. 68-72

DataStudio Software ..... p. 86-89

Charge of an Electron

EX-9929

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.

Experiment Includes:

Millikan Oil Drop Apparatus	AP-8210
Basic Digital Multimeter	SE-9786
High Voltage Power Supply	SF-9585A
Large Rod Base	ME-8735
45 cm 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	

NEW **Downloads Available**

Each experiment manual and the DataStudio files may be downloaded free at **www.pasco.com**

Type the experiment number EX-XXXX into the search box to find the download information.

Order Information:

Charge of an Electron **EX-9929**

Resistivity

EX-9966 Xplorer GLX

Concepts:

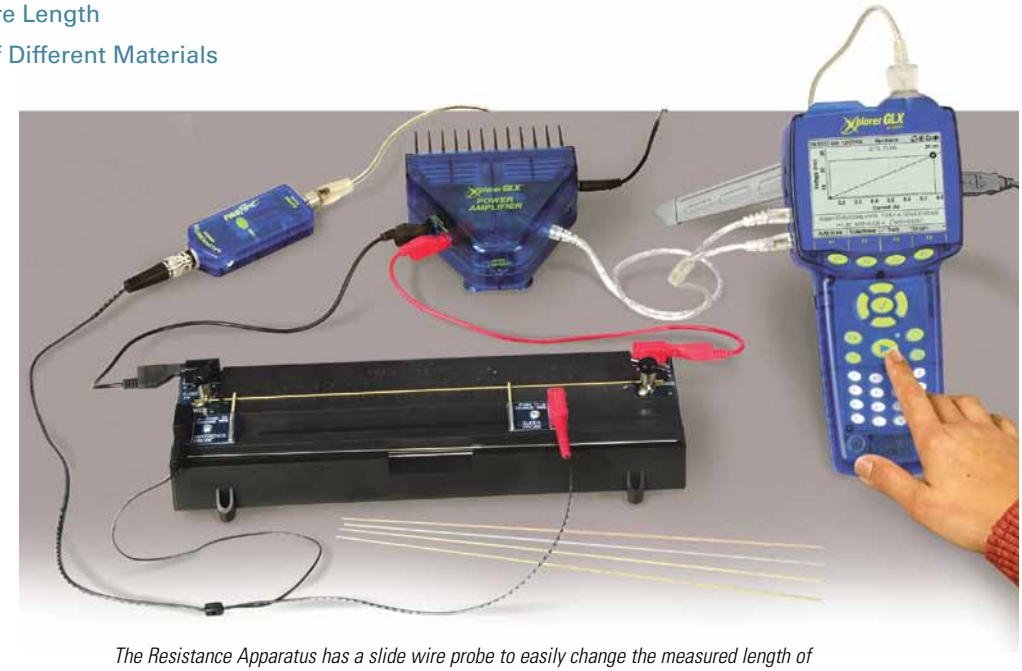
- Relate Resistance to Wire Length
- Determine Resistivity of Different Materials

Discover the relationship between the resistance of a wire and its length, diameter, and the resistivity of the metal.

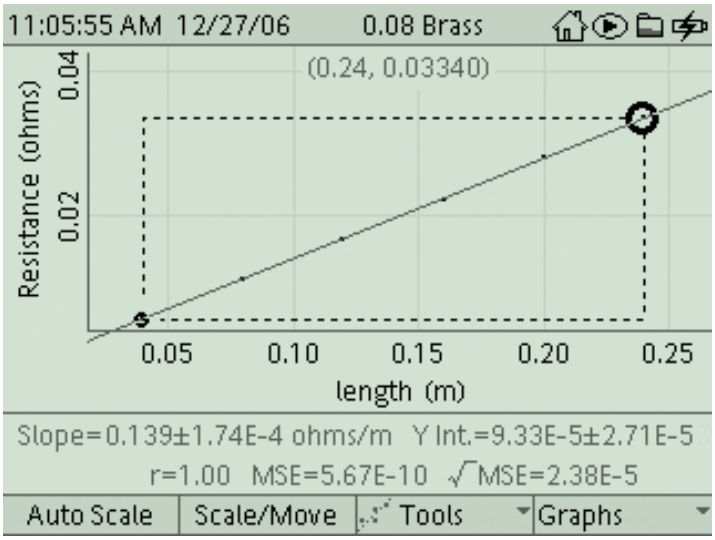
The GLX Power Amplifier produces a 10 second voltage ramp, resulting in a varying current through a straight wire. The current is measured directly by the Power Amplifier, and the voltage drop over the selected section of wire is measured by the Galvanometer Sensor.

A graph of voltage drop vs. current is created, and the slope of the line is the resistance of the length of wire. The resistance is plotted versus the length of the wire and the slope of the resulting straight line is used to determine the resistivity.

GLX Power Amplifier is designed to work with the Xplorer GLX to provide AC/DC power. In this application, the ramp function is used to sweep through the voltages.



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.



The resistances of various lengths of the 0.0813 cm diameter brass wire are determined, and a graph of resistance vs. wire length is made. The slope of this graph along with the diameter of the wire gives a resistivity of 7.2 x 10 -8 Ω•m for the brass material.

PASCO Advantage

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.

The Xplorer GLX Amplifier makes it possible to scan the voltages, allowing more time to examine wires made of different metals and having different diameters.

Experiment Includes:

Resistance Apparatus	EM-8812
GLX Power Amplifier	PS-2006
Galvanometer Sensor	PS-2160
Patch Cords	SE-9750
Resistivity Experiment Manual	
Xplorer GLX Files for Resistivity Experiment	
DataStudio Lite Software	

NEW Downloads Available

Each experiment manual and the DataStudio files may be downloaded free at **www.pasco.com**

Type the experiment number EX-XXXX into the search box to find the download information.

Order Information:

Resistivity **EX-9966**

Required:

Xplorer GLX ..... p. 10

Ohm's Law

EX-9949 *ScienceWorkshop*
EX-9953 PASPORT

Concepts:

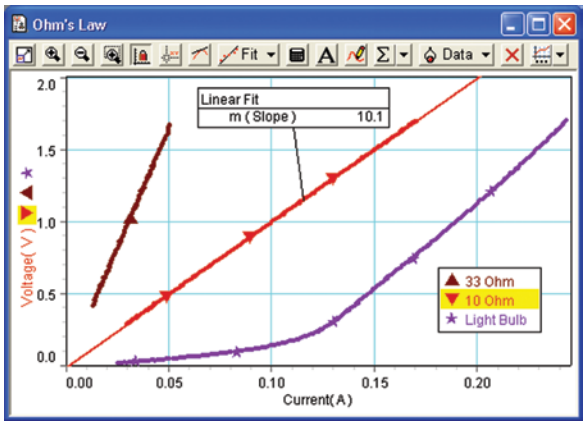
- Compact Design
- Relationship between Voltage and Current
- Uses Capacitor as a Variable Voltage Source

Method

In this experiment, students simultaneously measure both current and voltage for a simple DC circuit. The relationship between current and voltage is explored for a 10 Ω resistor, 33 Ω resistor, and a light bulb.

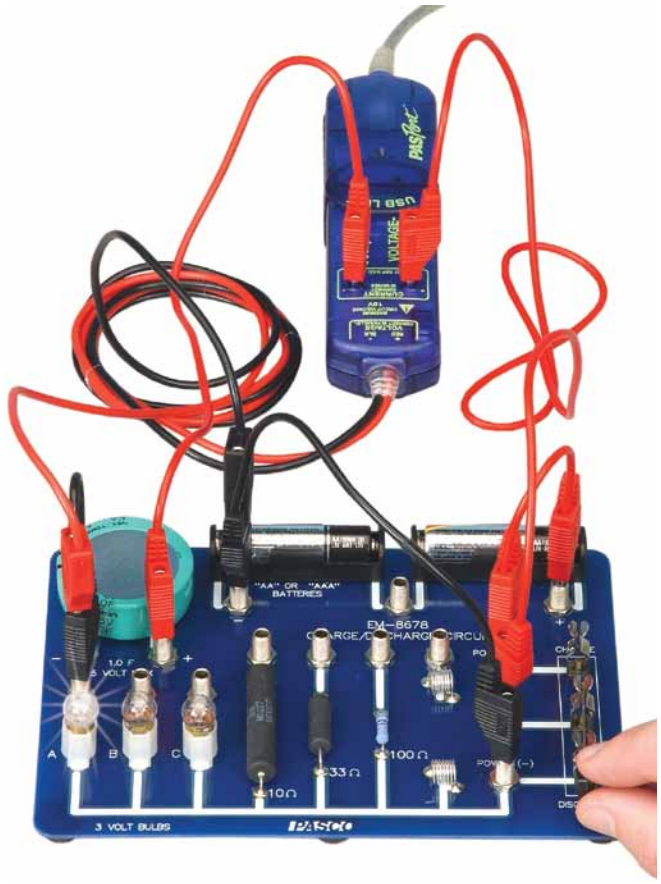
Prior to performing the Ohm's Law experiment, students study the characteristics of a capacitor by recording current and voltage measurements during both the charging and discharging cycles. Once the function of a capacitor is better understood, the capacitor is used as a variable voltage source during the Ohm's Law experiment.

The relationship between current and voltage is studied for each resistor and the light bulb to determine their similarities and differences.



The relationship between voltage and current varies for different electrical components. The resistance of the light bulb filament increases with temperature.

Experiment Includes:	EX-9949 *ScienceWorkshop*	EX-9953 PASPORT
Charge/Discharge Circuit	EM-8678	EM-8678
Voltage Sensor	CI-6503	*not needed*
Current Sensor	CI-6556	*not needed*
Voltage-Current Sensor	*not needed*	PS-2115
AA Batteries	PI-6601	PI-6601
Short Patch Cords	SE-7123	SE-7123
Ohm's Law Experiment Manual		
DataStudio Files for Ohm's Law Experiment		
DataStudio Lite Software		



Voltage across and current through the light bulb are measured real-time as the capacitor discharges.

PASCO Advantage

Using a capacitor as a variable voltage source allows the experiment to be easily repeated for several loads. Students can view the voltage vs. current graph real-time which allows them to see the relationship unfold before their eyes. Furthermore, the tangent tool on the DataStudio graph enables students to easily determine resistance of the light bulb at any instant.

The included AA batteries charge the capacitor, and thus no other power supply is needed.

NEW Downloads Available

Each experiment manual and the DataStudio files may be downloaded free at **www.pasco.com**
Type the experiment number EX-XXXX into the search box to find the download information.

Order Information:

Ohm's Law (*ScienceWorkshop*) **EX-9949**
Ohm's Law (PASPORT) **EX-9953**
Required for use with ScienceWorkshop:
ScienceWorkshop 500, 700 or *750* Interface ..... p. 68-72
Required for use with PASPORT:
PASPORT Interface ..... p. 10-23

RC Circuit

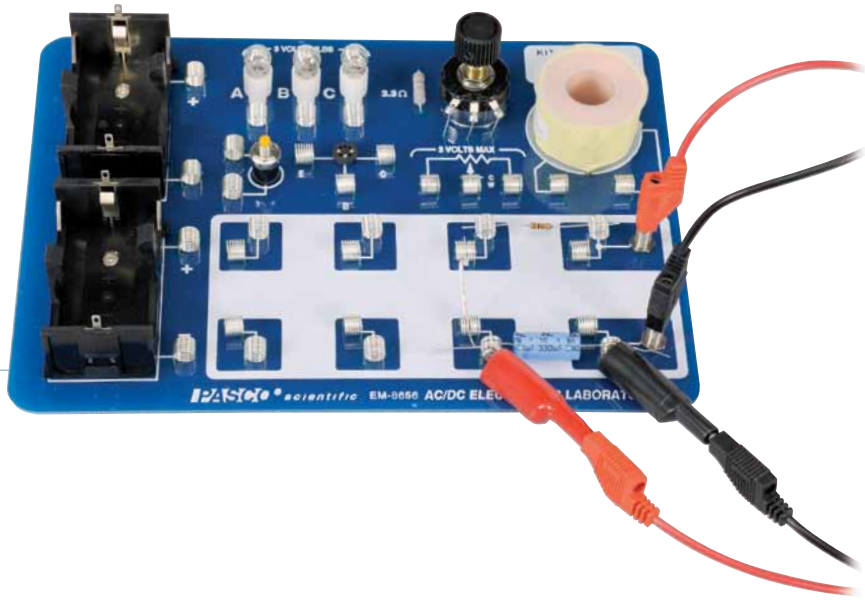
EX-9986 *ScienceWorkshop*

NEW

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.



Experiment Includes:

AC/DC Electronics Lab	EM-8656
Voltage Sensor	CI-6503
Banana Plug (5 pack)	SE-9750
Alligator Clip Adapters (10 pack)	SE-9756
RC Circuit Experiment Manual	
DataStudio File for RC Circuit Experiment	
DataStudio Lite Software	

NEW **Downloads Available**

Each experiment manual and the DataStudio files may be downloaded free at **www.pasco.com**

Type the experiment number EX-XXXX into the search box to find the download information.

Order Information:

RC Circuit	**EX-9986**
Required:	
ScienceWorkshop 500 or *750* Interface	p. 68-72
DataStudio Software	p. 86-89

LRC Circuit

EX-9915 *ScienceWorkshop*

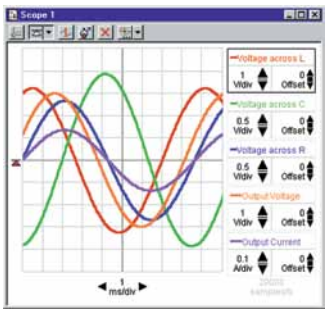
Concepts:

- LC Oscillations
- Inductive, Capacitive and Resistive AC Circuits
- LRC Resonant Frequency

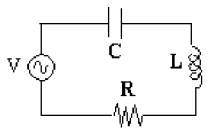
The response of a series LRC circuit is examined at driving frequencies above, below and at the resonant frequency.

First, a square wave voltage is applied to an LC circuit and the period of oscillation of the voltage across the capacitor is measured and compared to the theoretical value. Then three AC circuits are examined: 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 750 Interface supplies AC voltage to an LRC series circuit.



The oscilloscope display in DataStudio is used to simultaneously display the voltages across the inductor, capacitor and resistor, as well as the source voltage and current.



Experiment Includes:

AC/DC Electronics Laboratory	EM-8656
Voltage Sensors (3)	CI-6503
Banana Plug Cord (30 cm, Set of 8)	SE-7123
LRC Circuit Experiment Manual	
DataStudio File for LRC Circuit Experiment	
DataStudio Lite Software	

NEW **Downloads Available**

Each experiment manual and the DataStudio files may be downloaded free at **www.pasco.com**

Type the experiment number EX-XXXX into the search box to find the download information.

Order Information:

LRC Circuit	**EX-9915**
Required:	
ScienceWorkshop 750 Interface	p. 68-72
DataStudio Software	p. 86-89

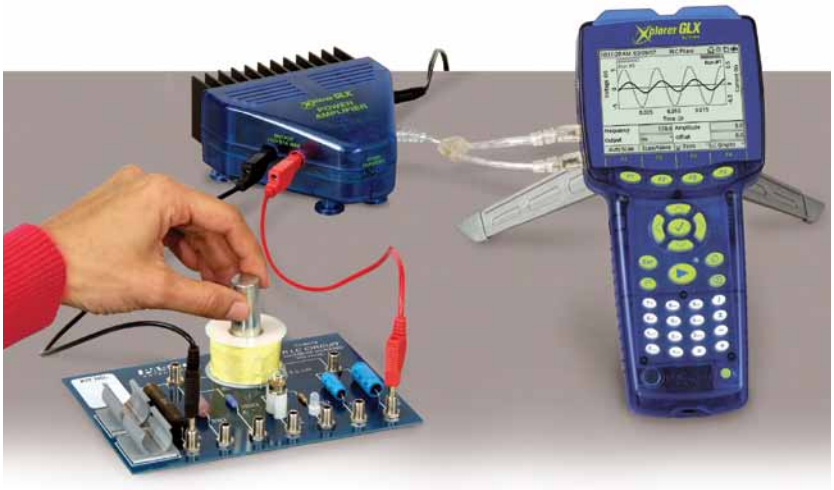
LRC Resonance

EX-9967 Xplorer GLX

Concepts:

- Plot Resonance Curves for LRC Series Circuit
- Examine Differences when R and L are Changed
- Phase Difference vs. Driving Frequency

To study the resonance curve for a series LRC circuit, the Xplorer GLX Power Amplifier is used to automatically scan through the driving frequencies while simultaneously measuring the response current. The amplitude of the current is plotted versus frequency and the resonant frequency is determined. The value of the resistance is changed to see how the resonance curve changes.

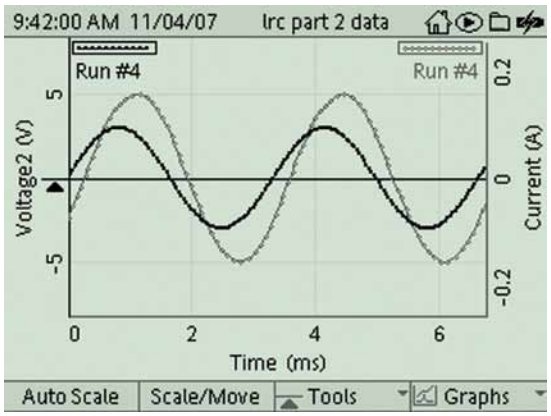


The RLC Circuit Board is powered using the Xplorer GLX to control the output of the Xplorer GLX Power Amplifier.

Using the scope mode of the Xplorer GLX, the phase difference between the driving voltage and the resulting current is measured at low frequency, resonant frequency, and high frequency, and compared to theory.

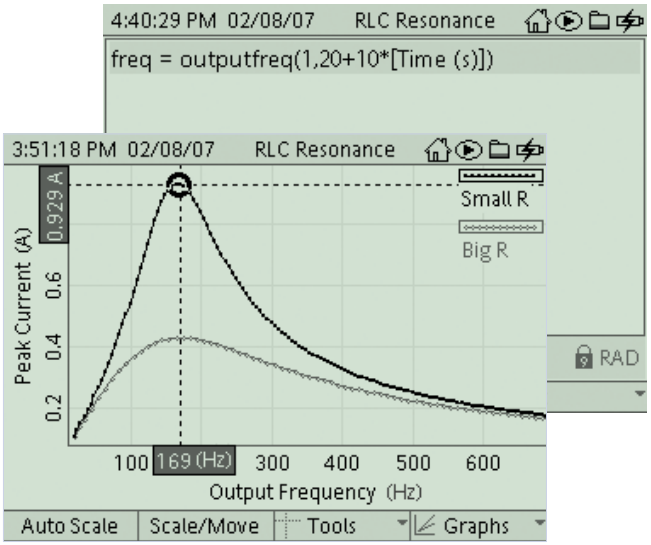
The CI-6512 RLC Circuit Board is perfect for studying introductory AC Circuit Theory. Vary all parameters, including resistance, capacitance, and even the inductance of the coil by using the included iron core.

GLX Power Amplifier is designed to work with the Xplorer GLX to provide AC/DC power for heat, sound, vibration, and electronic studies. Adjust Waveform, Frequency, Voltage Amplitude, DC Offset and more, directly from the GLX.



The scope mode of the Xplorer GLX is used to measure the phase difference between the driving voltage and the current at various frequencies.

Use the built-in calculator on the GLX to automatically sweep the output frequency of the Power Amplifier through the desired range.



The graph shows the resonance curves for two different resistance values, with a 100 µF capacitor and the 8.2 mH coil (without iron core). The theoretical resonance frequency for these values is 176 Hz.

Experiment Includes:

RLC Circuit Board	CI-6512
GLX Power Amplifier	PS-2006
Patch Cords	SE-7123
LRC Resonance Experiment Manual	
Xplorer GLX Files for LRC Resonance Experiment	
DataStudio® Lite Software	

NEW Downloads Available

Each experiment manual and the DataStudio files may be downloaded free at **www.pasco.com**

Type the experiment number EX-XXXX into the search box to find the download information.

Order Information:

LRC Resonance **EX-9967**

Required:

Xplorer GLX ..... p. 10

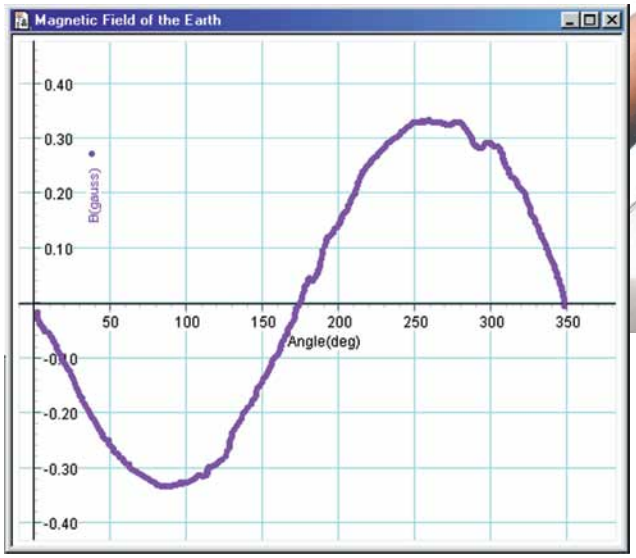
Earth's Magnetic Field

EX-9913 *ScienceWorkshop*
EX-9968 PASPORT

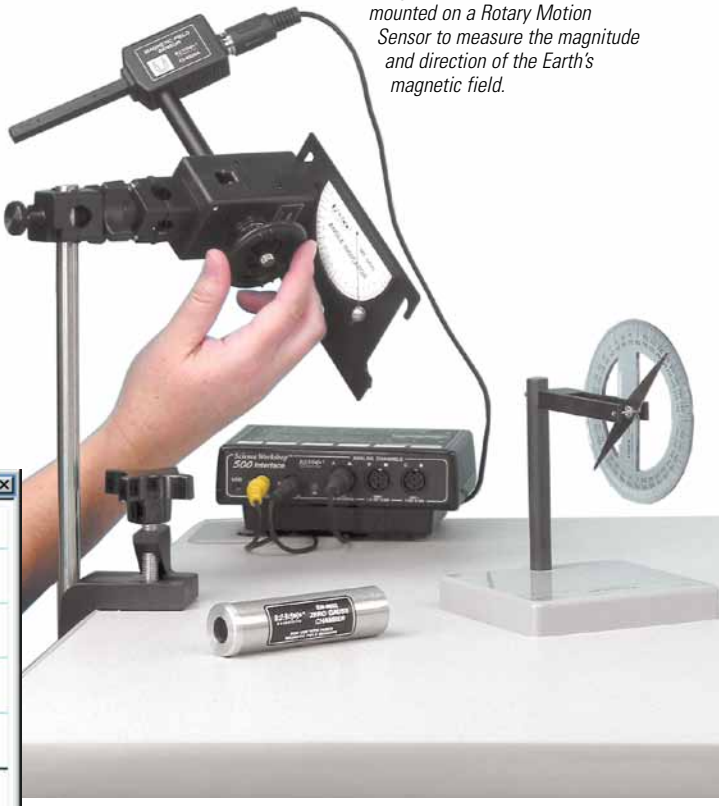
Concepts:

- Magnitude of the Earth's Magnetic Field
- Direction of Earth's Magnetic Field
- Dip Angle

The magnitude and direction of the Earth's magnetic field are measured using a Magnetic Field Sensor mounted on a Rotary Motion Sensor. The Magnetic Field Sensor is rotated through 360 degrees by rotating the Rotary Motion Sensor pulley by hand. The Magnetic Field Sensor is zeroed using the Zero Gauss Chamber, the walls of which are made of a highly permeable material which redirects the magnetic field around the chamber.



The Earth's magnetic field is measured as the Magnetic Field Sensor is rotated 360 degrees in the Earth's field.



The Magnetic Field Sensor is mounted on a Rotary Motion Sensor to measure the magnitude and direction of the Earth's magnetic field.

Experiment Includes:	EX-9913 *ScienceWorkshop*	EX-9968 PASPORT
Magnetic Field Sensor	CI-6520A	
2-Axis Magnetic Field Sensor		PS-2162
Zero Gauss Chamber	EM-8652	EM-8652
Rotary Motion Sensor	CI-6538	PS-2120
Dip Needle	SF-8619	SF-8619
Large Table Clamp	ME-9472	ME-9472
45 cm Stainless (non-magnetic) Steel Rod	ME-8736	ME-8736
Adjustable Angle Clamp	ME-8744	ME-8744
Angle Indicator	ME-9495	ME-9495
Earth's Magnetic Field Experiment Manual		
DataStudio File for Earth's Magnetic Field Experiment		

PASCO Advantage

The sensitive Magnetic Field Sensor combined with the Rotary Motion Sensor enables the measurement of the magnetic field strength as a function of angle from North. It is essentially a computerized compass that can measure both the direction and the magnitude of the field.

NEW Downloads Available

Each experiment manual and the DataStudio files may be downloaded free at
www.pasco.com
Type the experiment number EX-XXXX into the search box to find the download information.

Order Information:

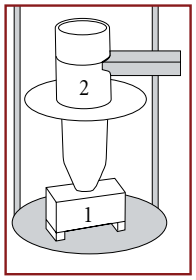
Earth's Magnetic Field (*ScienceWorkshop*) **EX-9913**
Earth's Magnetic Field (PASPORT) **EX-9968**
Required for use with ScienceWorkshop:
ScienceWorkshop 500 or 750 Interface ..... p. 68-72
DataStudio Software ..... p. 86-89
Required for use with PASPORT:
PASPORT Interface ..... p. 10-23
DataStudio Software ..... p. 86-89

Magnetic Forces on Wires

EX-9933

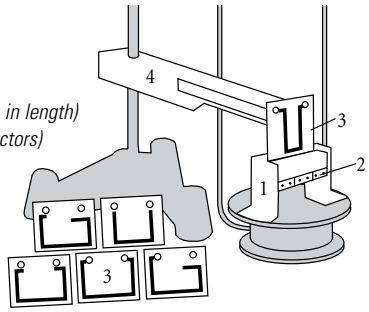
Concepts:

- Relationship between:
  Force and Current, Force and Length of Wire,
  Force and Magnetic Field Strength, Force and Angle



1. *Fixed Magnet with Yoke*
2. *10-turn Rectangular Coil (with a built-in degree scale)*

1. *Iron Yoke (holds magnets)*
2. *Removable Magnets (six)*
3. *Six Conductors (1, 2, 3, 4, 6 and 8 cm in length)*
4. *Mount (for holding/positioning conductors)*

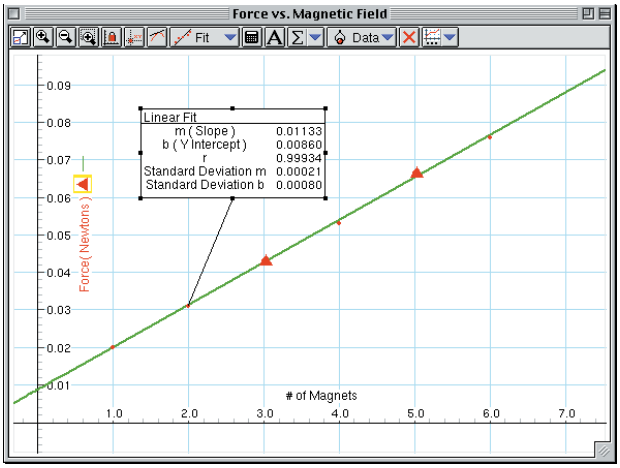


Magnets are mounted on an iron yoke and placed on a balance (resolution of at least 0.01 g). One of the conducting paths is suspended between the magnets. The balance is used to measure the mass of the magnets and yoke prior to any current passing through the conducting path. Current is then passed through the conducting path, producing a force. The change in reading on the balance can be converted to find the magnetic force between the conductor and magnetic field.

Conductors of different length are included to measure the effect of length on magnetic force. Magnetic field can be varied by changing the number of magnets in the yoke. The power source is used to change the current supplied to the conductor. The Current Balance Accessory includes all the components needed to test the effect of angle on magnetic force.

PASCO Advantage

PASCO's Magnetic Force in Wires Experiment allows students to study the key variables (conductor length, current, magnetic field strength and angle) that affect magnetic force.



Graph illustrates the direct relationship between magnetic field and magnetic force.

Experiment Includes:

Basic Current Balance	SF-8607
Current Balance Accessory	SF-8608
Ohaus Cent-o-Gram Balance	SE-8725
Low Voltage AC/DC Power Supply	SF-9584A
Large Base and Support Rod	ME-9355
Banana Plug Cord-Red (5 pack)	SE-9750
Banana Plug Cord-Black (5 pack)	SE-9751
Magnetic Forces on Wires Experiment Manual	

NEW **Downloads Available**

Each experiment manual and the DataStudio files may be downloaded free at
www.pasco.com
Type the experiment number EX-XXXX into the search box to find the download information.

Order Information:

Magnetic Forces on Wires.....EX-9933

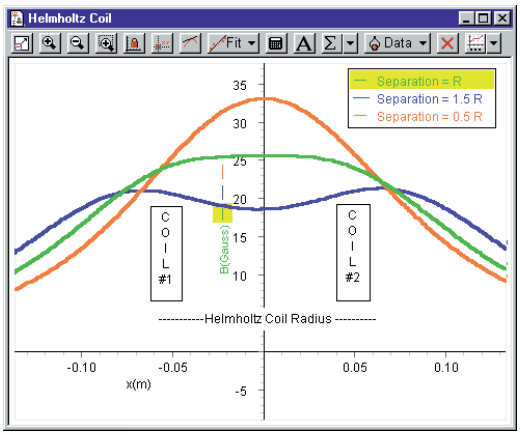
Magnetic Fields of Coils

EX-9931 *ScienceWorkshop*

Concepts:

- Magnetic Fields of:
  - Single Coil
  - Helmholtz Coils
  - Inside a Solenoid

The magnetic field of Helmholtz coils is measured as a function of distance along the perpendicular axis.



This plot shows the magnetic field strength along the axis of Helmholtz coils for three different coil separations: The green data is for coils with the proper separation (the coil radius), the orange data is for the coils too close together and the blue data is for the coils too far apart.

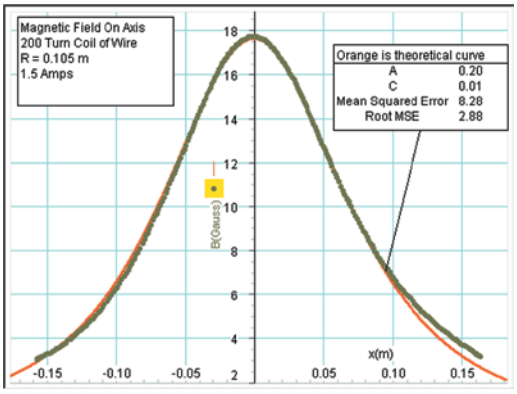
The dependence of the magnetic field strength of current-carrying coils on the distance from the coil along the perpendicular axis is determined and compared to the theoretical curve. In addition, the effect of varying the coil separation on the shape of the magnetic field between the Helmholtz coils is examined.

The magnetic fields of various coils are plotted versus position as the Magnetic Field Sensor is passed through the coils, guided by a track. The position is recorded by a string attached to the Magnetic Field Sensor that passes over the Rotary Motion Sensor pulley to a hanging mass.

It is particularly interesting to compare the field from Helmholtz coils at the proper separation of 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.

The magnetic field inside a solenoid is measured in the radial and axial directions.



The olive green curve is the measured magnetic field versus distance along the perpendicular axis of a single coil. The orange theoretical curve is plotted from an equation.

PASCO Advantage

Using DataStudio curve fit, the theoretical equation for the magnetic field can be plotted on the same graph.

Experiment Includes:

Helmholtz Coil Base	EM-6715
Field Coil (200 Turn) (2)	EM-6711
Primary and Secondary Coils	SE-8653
Banana Plug Cord-Red (5 pack)	SE-9750
Banana Plug Cord-Black (5 pack)	SE-9751
60 cm Optics Bench	OS-8541
Dynamics Track Mount	CI-6692
Hooked Mass Set	SE-8759
Small Round Base (2)	ME-8974
25 cm Steel Rod (2)	ME-8988
Optics Bench Rod Clamps (2)	OS-8479
DC Power Supply	SE-9720
Digital Multimeter	SE-9786A
Magnetic Field Sensor	CI-6520A
Rotary Motion Sensor	CI-6538
Magnetic Field of Coils Experiment Manual	
DataStudio File for Magnetic Fields of Coils Experiment	

NEW Downloads Available

Each experiment manual and the DataStudio files may be downloaded free at
www.pasco.com
Type the experiment number EX-XXXX into the search box to find the download information.

Order Information:

Magnetic Fields of Coils **EX-9931**

Required:

ScienceWorkshop 500 or *750* Interface ..... p. 68-72

DataStudio Software ..... p. 86-89

Faraday's Law of Induction

EX-9914 *ScienceWorkshop*

EX-9957 PASPORT
(with computer or stand-alone Xplorer GLX)

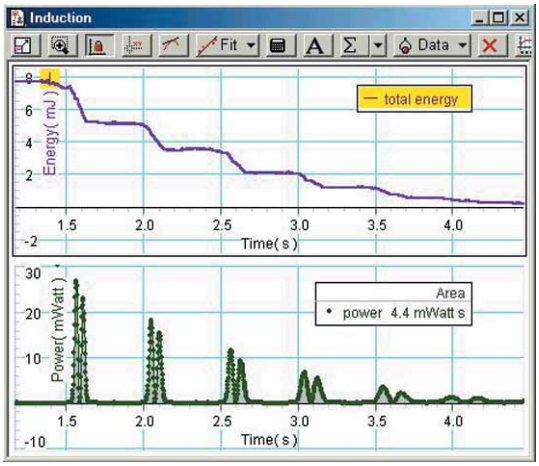
Concepts:

- 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 Voltage Sensor. The angle is measured with a Rotary Motion Sensor, which also acts as a pivot for the pendulum. The induced voltage is plotted versus 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 versus time curve. This energy is compared to the loss of energy determined from the amplitude and speed of the pendulum.

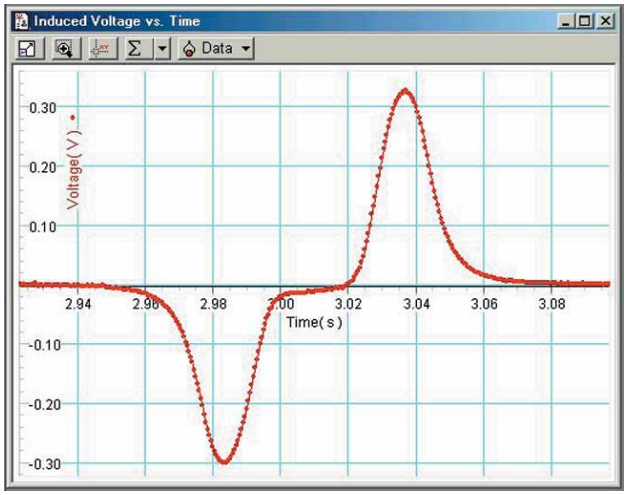
Faraday's Law is used to estimate the magnetic field of the magnet from the maximum induced voltage. Also, the direction of the induced voltage as the coil enters and leaves the magnetic field is examined and analyzed using Lenz's Law.



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 versus time plot.

Experiment Includes:	EX-9914 *ScienceWorkshop*	EX-9957 PASPORT
Induction Wand	EM-8099	EM-8099
Variable Gap Magnet	EM-8641	EM-8641
Large Rod Base	ME-8735	ME-8735
45 cm Steel Rod (2)	ME-8736	ME-8736
Multi-Clamp	SE-9442	SE-9442
Voltage Sensor	CI-6503	PS-2115
Magnetic Field Sensor	CI-6520A	PS-2162
Rotary Motion Sensor	CI-6538	PS-2120
Faraday's Law Experiment Manual		
DataStudio File for Faraday's Law Experiment		

A voltage is induced in a coil swinging through a magnetic field.



Plot of voltage versus time.

PASCO Advantage

The DataStudio calculator calculates energy and power using the voltage and angle data. The induced voltage and the calculations are plotted in real-time as the coil swings through the magnet.

NEW Downloads Available

Each experiment manual and the DataStudio files may be downloaded free at
www.pasco.com
Type the experiment number EX-XXXX into the search box to find the download information.

Order Information:

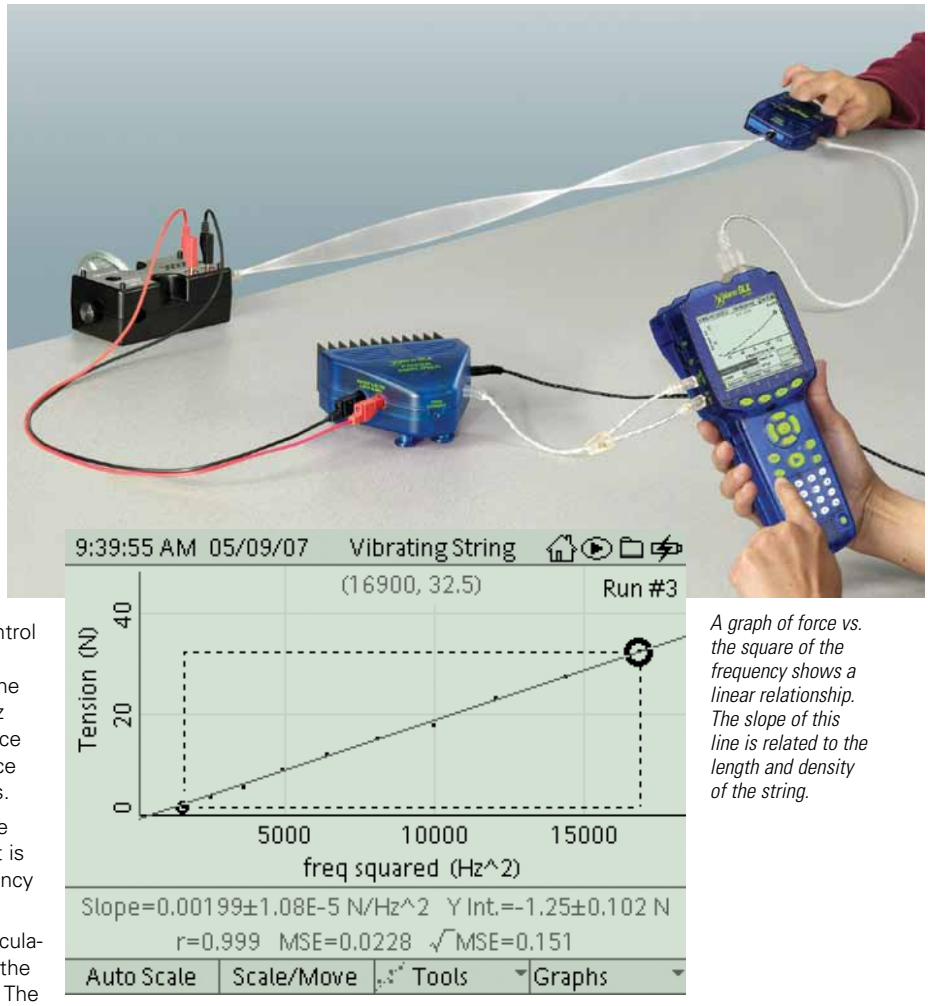
Faraday's Law of Induction
(*ScienceWorkshop*) **EX-9914**
Faraday's Law of Induction (PASPORT) **EX-9957**
Required for use with ScienceWorkshop:
ScienceWorkshop 500 or 750 Interface ..... p. 68-72
DataStudio Software ..... p. 86-89
Required for use with PASPORT (with computers or stand-alone GLX):
PASPORT Interface ..... p. 10-23
DataStudio Software (if used with computers) ..... p. 86-89

Vibrating String

EX-9964 Xplorer GLX

Concepts:

- Investigate Standing Waves
- Pull String to Adjust Number of Segments
- Vary Frequency of Vibration



A graph of force vs. the square of the frequency shows a linear relationship. The slope of this line is related to the length and density of the string.

Study standing waves in a string by varying the driver frequency and keeping the number of segments constant. The unusual approach in this version of the experiment is that the students actually provide the tension in the string by pulling directly on the force sensor. This is particularly instructive because the students get a feel for how the tension must change to vary the number of segments. Rather than hanging more weight over a pulley, the students must pull harder to achieve a smaller number of segments. This helps them remember the relationship between tension and wavelength.

The Xplorer GLX and Power Amplifier control the frequency and amplitude of the sine waves applied to the String Vibrator. As the frequency is gradually increased (in 10 Hz increments), the student pulls on the Force Sensor to adjust the tension for resonance with the string vibrating in two segments.

Using the Manual Sampling Mode, on the Xplorer GLX, each discrete measurement is recorded, and a graph of force vs. frequency is created in real-time.

To analyze the data, the GLX's built-in calculator is used to create a graph of force vs. the square of the frequency (shown at right). The slope of the resulting straight line is used (along with the length of the string) to calculate an experimental value for the string's density.

Experiment Includes:

String Vibrator	WA-9857
Physics String	SE-8050
GLX Power Amplifier	PS-2006
Force Sensor	PS-2104
C-clamp (small)	SE-7286
Patch Cords	SE-9750
Tape Measure	SE-8712A

Vibrating String Experiment Manual
Xplorer GLX Files for Vibrating String Experiment
DataStudio Lite

PASCO Advantage

The string tension is measured directly with a Force Sensor, enabling students to feel the force required to obtain a certain number of segments.

Set-up and execution of this experiment is extremely easy because no connection to a computer is necessary. All data analysis can be performed on the Xplorer GLX and the results can be printed directly to a variety of HP USB printers.

NEW Downloads Available

Each experiment manual and the DataStudio files may be downloaded free at **www.pasco.com**
Type the experiment number EX-XXXX into the search box to find the download information.

Order Information:

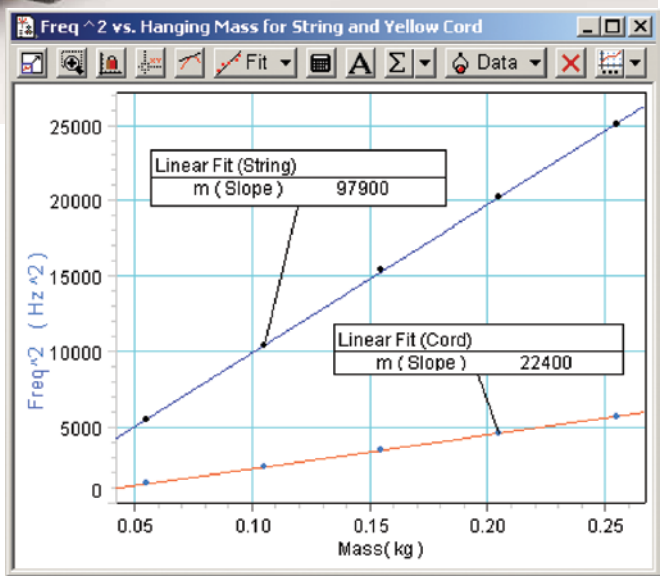
Vibrating String **EX-9964**
Required:
Xplorer GLX ..... p. 10

Waves

EX-9952

Concepts:

- Speed of Waves in a String
- Speed of Sound in Air
- Resonance in Strings and Air Columns
- Harmonics



Graphs of the square of the frequency versus the hanging mass for two different types of strings have different slopes corresponding to different string densities.

Standing waves in strings and air columns are studied. 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. For the 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 closed versus open tubes.

Experiment Includes:

String Vibrator	WA-9857
Sine Wave Generator	WA-9867
Open Speaker	WA-9900
Economy Resonance Tube	WA-9495
Elastic Wave Cord	SE-9409
Physics String	SE-8050
Yellow Braided Cord	699-067
Drilled Mass and Hanger Set	ME-8967
Universal Table Clamp (2)	ME-9376B
Adjustable Angle Clamp	ME-8744
Super Pulley	ME-9450
Pulley Mounting Rod	SA-9242
45 cm Rod (2)	ME-8736
Banana Plug Cord Set, Red	SE-9750
Waves Experiment Manual	
DataStudio Lite Software (for graphing)	

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.

NEW **Downloads Available**

Each experiment manual and the DataStudio files may be downloaded free at **www.pasco.com**

Type the experiment number EX-XXXX into the search box to find the download information.

Order Information:

Waves **EX-9952**

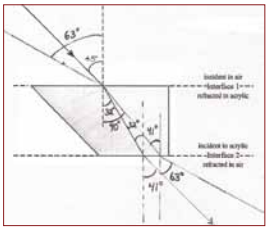
Reflection and Refraction

EX-9987

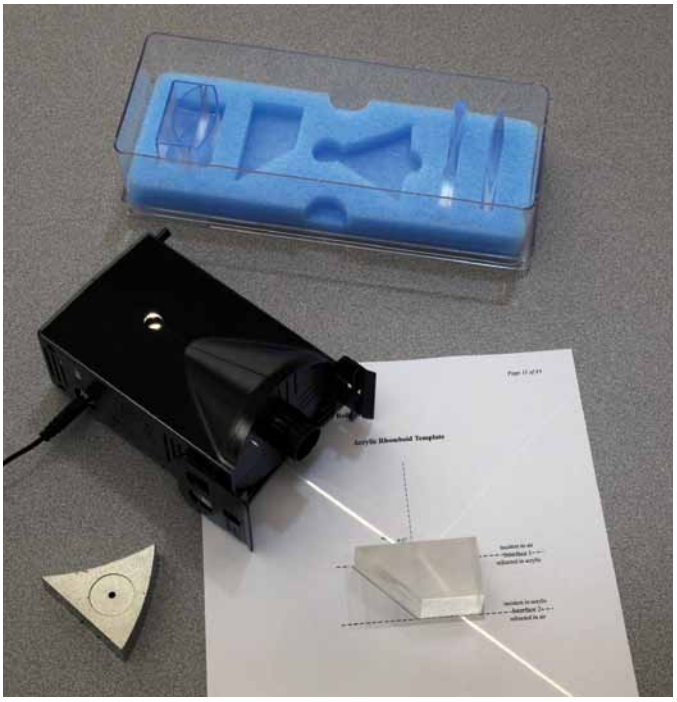
Concepts:

- Reflection and Refraction
- Index of Refraction

Students experimentally derive the Law of Reflection for curved and flat mirrors. Snell's law is explored for both concave and convex lenses and the index of refraction for a piece of acrylic material is found.



Students trace rays on the provided templates.



Experiment Includes:

Ray Optics Kit	OS-8516
Basic Optics Light Source	OS-8470
Reflection and Refraction Experiment Manual	

Downloads Available

Each experiment manual and the DataStudio files may be downloaded free at **www.pasco.com**

Type the experiment number EX-XXXX into the search box to find the download information.

Order Information:

Reflection and Refraction **EX-9987**

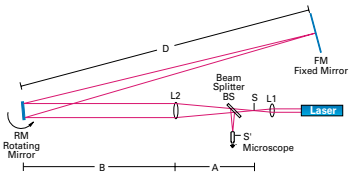
Required:
Protractor and Ruler

Speed of Light

EX-9932

Concepts:

- Determine the Speed of Light in Air
- Recreate Foucault's Historical Experiment



CLASS II LASER PRODUCT
LASER RADIATION – DO NOT STARE INTO BEAM OR
VIEW DIRECTLY WITH OPTICAL INSTRUMENTS

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 final/initial positions, angular velocity of the rotating mirror and distance traveled by the light are then used to calculate the speed of light in air.

Experiment Includes:

Complete Speed of Light Apparatus	OS-9261A
Speed of Light Experiment Manual	

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.

Downloads Available

Each experiment manual and the DataStudio files may be downloaded free at **www.pasco.com**

Type the experiment number EX-XXXX into the search box to find the download information.

Order Information:

Speed of Light **EX-9932**

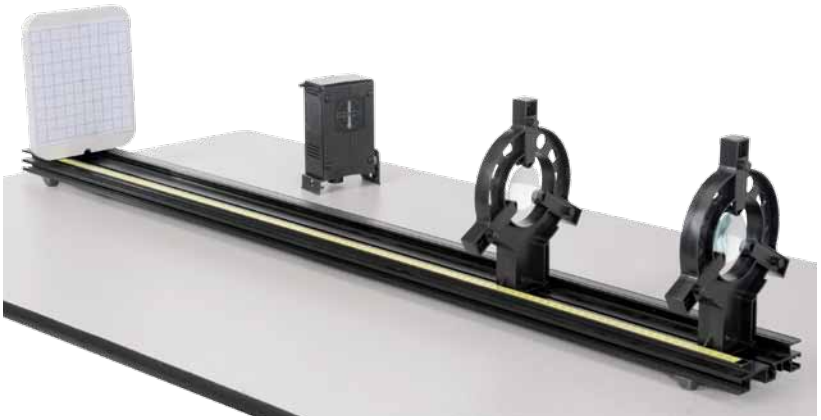
Telescope/Microscope

EX-9988

NEW

Concepts:

- Multiple Lens Systems
- Magnification
- Parallax
- 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 method parallax is used to locate virtual images. Students draw ray diagrams and measure the magnification of the instruments.

Experiment Includes:

Beginning Optics System	OS-8459
Includes:	
Basic Optics Light Source	OS-8470
Adjustable Lens Holders	OS-8474
Geometric Lens Set	OS-8456
Viewing Screen	OS-8460
1.2m Optics Bench	OS-8508

NEW **Downloads Available**

Each experiment manual and the DataStudio files may be downloaded free at **www.pasco.com**

Type the experiment number EX-XXXX into the search box to find the download information.

Order Information:

Telescope and Microscope **EX-9988**

Required:

Rubber Bands and Ruler

Polarization of Light

EX-9917A *ScienceWorkshop*

EX-9958 PASPORT

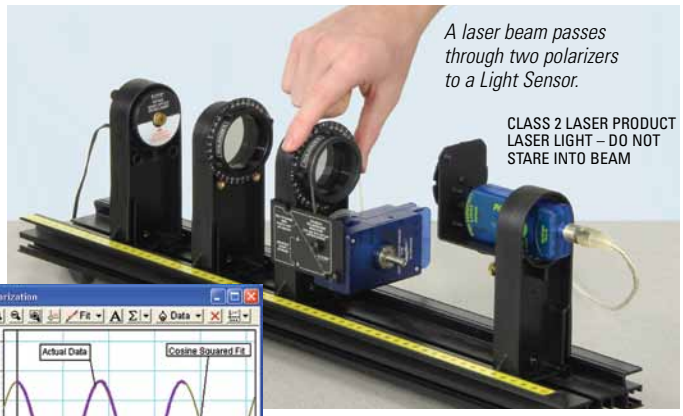
Malus' Law of Polarization

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.

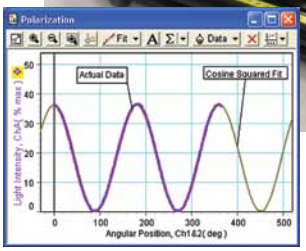
Laser light (peak wavelength = 650 nm) is passed through two polarizers. As the second polarizer (the analyzer) is rotated by hand, the relative light intensity is recorded as a function of the angle between the axes of polarization of the two polarizers. The angle is obtained using a Rotary Motion Sensor coupled to the polarizer with a drive belt. The plot of light intensity versus angle can be fitted to the square of the cosine of the angle.

PASCO Advantage

Laser light is used in this experiment because its wavelength is more completely extinguished by the crossed polarizers.



A laser beam passes through two polarizers to a Light Sensor.



As the polarizer is rotated, the intensity of the light varies as the square of the cosine of the angle between the two polarizers.

Experiment Includes:	EX-9917A *ScienceWorkshop*	EX-9958 PASPORT
Polarization Analyzer	OS-8533A	OS-8533A
Optics Bench (60 cm)	OS-8541	OS-8541
Rotary Motion Sensor	CI-6538	PS-2120
Light Sensor	CI-6504A	
High Sensitivity Light Sensor		PS-2176
Diode Laser	OS-8525A	OS-8525A
Polarization of Light Experiment Manual		
DataStudio Files for Polarization of Light Experiment		
DataStudio Lite		

NEW **Downloads Available**

Each experiment manual and the DataStudio files may be downloaded free at **www.pasco.com**

Type the experiment number EX-XXXX into the search box to find the download information.

Order Information:

Polarization of Light (*ScienceWorkshop*) **EX-9917A**

Polarization of Light (PASPORT) **EX-9958**

Required for use with ScienceWorkshop:

ScienceWorkshop 500 or *750* Interface ..... p. 68-72

DataStudio Software ..... p. 86-89

Required for use with PASPORT:

PASPORT Interface ..... p. 10-23

DataStudio Software ..... p. 86-89

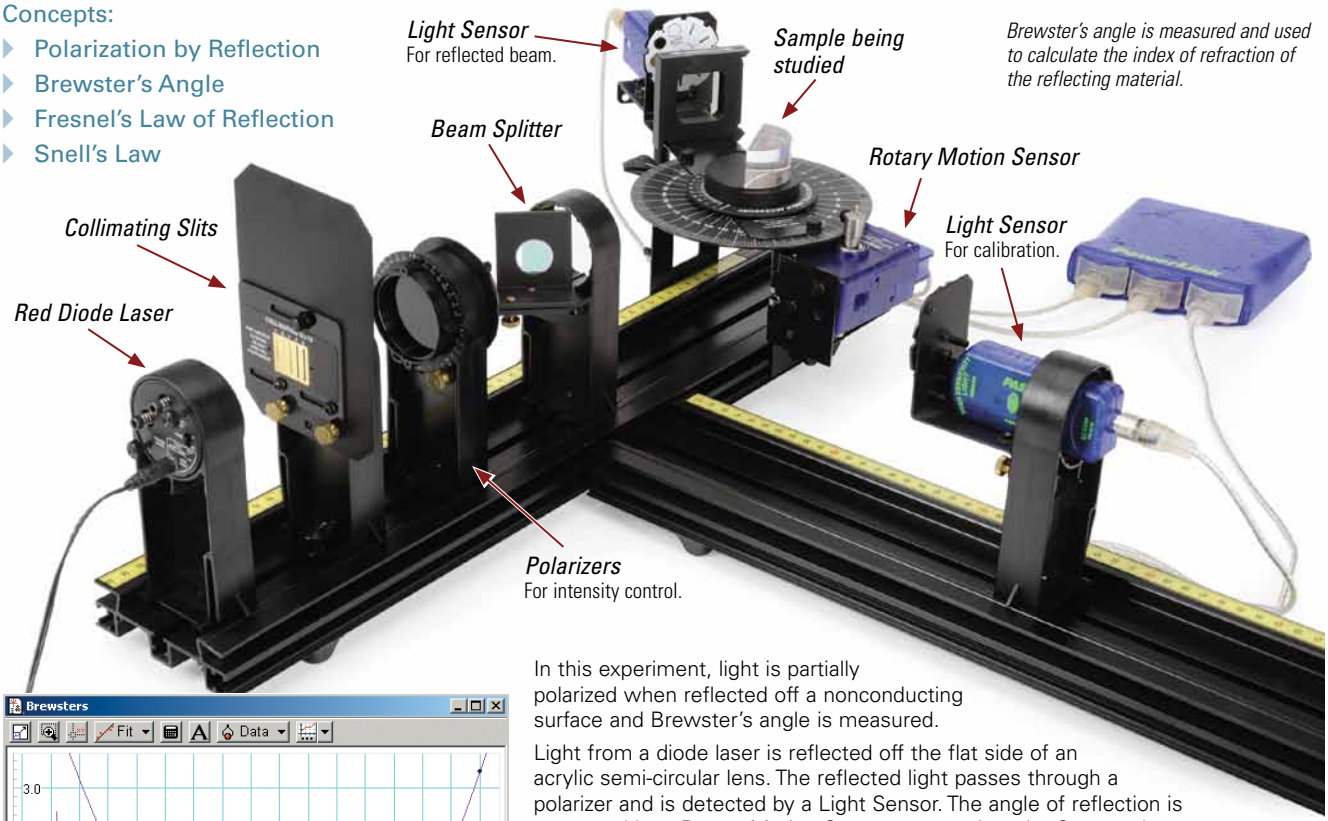
Brewster's Angle

EX-9919A *ScienceWorkshop* EX-9965A PASPORT

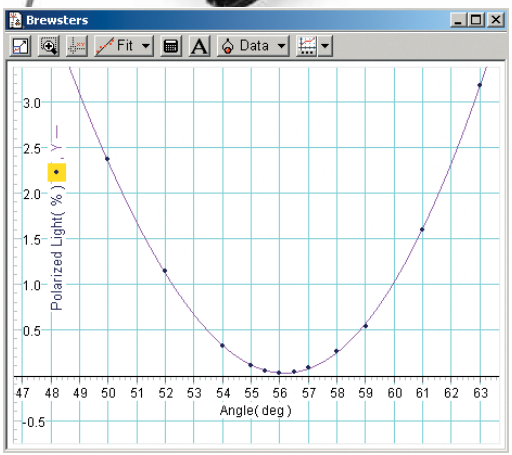
CLASS 2 LASER PRODUCT
LASER LIGHT – DO NOT STARE INTO BEAM

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.



Brewster's angle is determined by finding the angle at which no light is transmitted through the analyzing polarizer.

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 semi-circular 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 versus 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).

Experiment Includes:	EX-9919 *ScienceWorkshop*	EX-9965 PASPORT
Brewster's Angle Accessory	OS-8170A	OS-8170A
Spectrophotometer Accessory Kit	OS-8537	OS-8537
Optics Bench (60 cm) (2)	OS-8541	OS-8541
Aperture Bracket (2)	OS-8534A	OS-8534A
Red Diode Laser	OS-8525A	OS-8525A
Rotary Motion Sensor	CI-6538	PS-2120
High Sensitivity Light Sensor (2)	CI-6604	PS-2176
Rotary Motion Sensor	CI-6538	PS-2120
Brewster's Angle Experiment Manual		
DataStudio Files for Brewster's Angle Experiment		
DataStudio Lite Software		

NEW **Downloads Available**

Each experiment manual and the DataStudio files may be downloaded free at **www.pasco.com**
Type the experiment number EX-XXXX into the search box to find the download information.

Order Information:

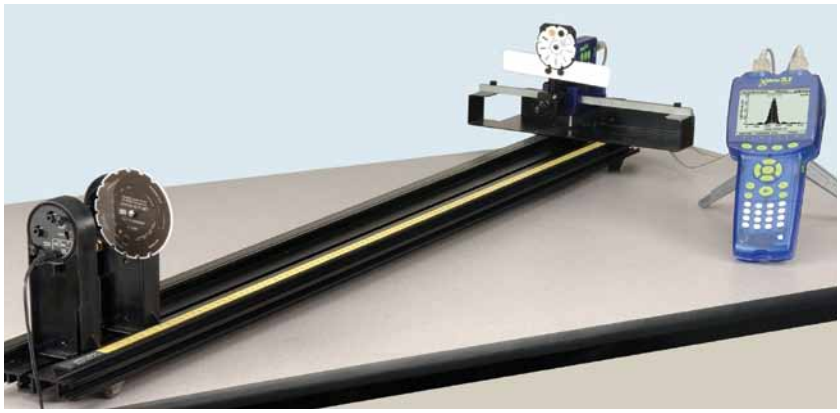
Brewster's Angle (*ScienceWorkshop*) **EX-9919A**
Brewster's Angle (PASPORT) **EX-9965A**
Required for use with ScienceWorkshop:
ScienceWorkshop 500 or 750 Interface ..... p. 68-72
DataStudio Software ..... p. 86-89
Required for use with PASPORT:
PASPORT Interface ..... p. 10-23
DataStudio Software ..... p. 86-89

Interference and Diffraction of Light

EX-9918 *ScienceWorkshop*
EX-9956 PASPORT Xplorer GLX

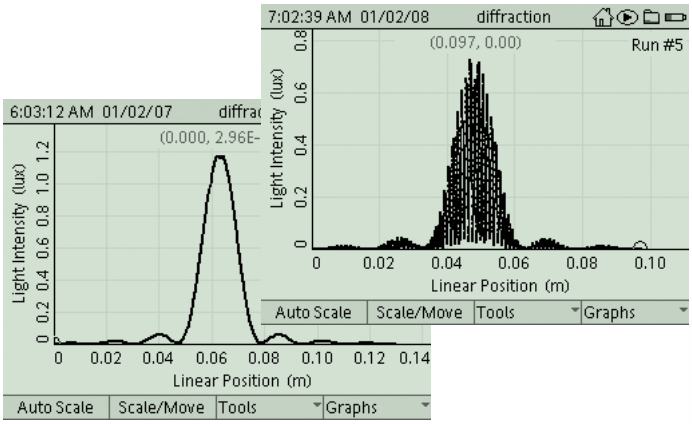
Concepts:

- Two-Slit Interference
- Single-Slit Diffraction
- Multiple-Slit Minor Maxima
- Slit Versus Line Diffraction

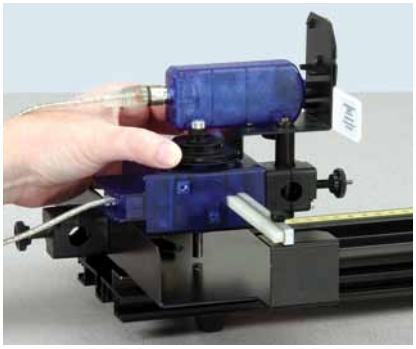


Interference and diffraction patterns from laser light passing through various single-slits and multiple-slits are scanned and plotted in real-time. These patterns are then examined for similarities and differences.

The 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 versus distance. Also, 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.

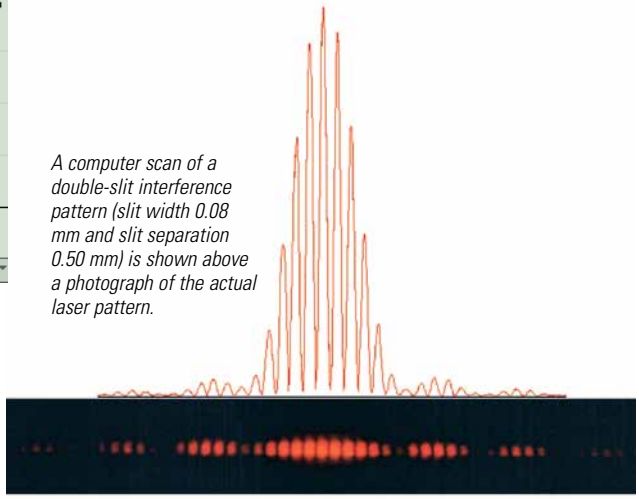


A GLX scan of double-slit interference pattern and single-slit diffraction pattern. The double slit and the single slit have the same slit width.



CLASS 2 LASER PRODUCT
LASER LIGHT – DO NOT STARE INTO BEAM

The laser interference pattern is scanned by hand with a Light Sensor on a Linear Translator.



A computer scan of a double-slit interference pattern (slit width 0.08 mm and slit separation 0.50 mm) is shown above a photograph of the actual laser pattern.

PASCO Advantage

Since the Linear Translator tracks the position of the Light Sensor, it is not necessary to move the Light Sensor at a constant speed. The intensity versus distance graph is plotted in real-time, showing the connection between the intensity pattern and the actual laser pattern. Adjustment of the slit size on the Light Sensor mask gives the resolution required to see detail in the interference patterns.

Experiment Includes:	EX-9918 *ScienceWorkshop*	EX-9956 PASPORT
1.2 m Optics Track	OS-8508	OS-8508
Diode Laser	OS-8525A	OS-8525A
Slit Accessories	OS-8523	OS-8523
Light Sensor	CI-6504A	PS-2176
Rotary Motion Sensor	CI-6538	PS-2120
Aperture Bracket	OS-8534	OS-8534
Linear Translator	OS-8535	OS-8535
Interference and Diffraction of Light Experiment Manual		
DataStudio File for Interference and Diffraction of Light Experiment		

NEW **Downloads Available**

Each experiment manual and the DataStudio files may be downloaded free at **www.pasco.com**
Type the experiment number EX-XXXX into the search box to find the download information.

Order Information:

Interference and Diffraction of Light (*ScienceWorkshop*) **EX-9918**
Interference and Diffraction of Light (PASPORT Xplorer GLX) **EX-9956**
Required for use with ScienceWorkshop:
ScienceWorkshop 500 or *750* Interface ..... p. 68-72
DataStudio Software ..... p. 86-89
Required for use with PASPORT:
PASPORT Xplorer GLX ..... PS-2002 p. 10
DataStudio Software ..... p. 86-89

Atomic Spectra

EX-9921 *ScienceWorkshop*
EX-9955 PASPORT

Concepts:

- Hydrogen Balmer Series
- Helium Spectrum
- Mercury Doublet

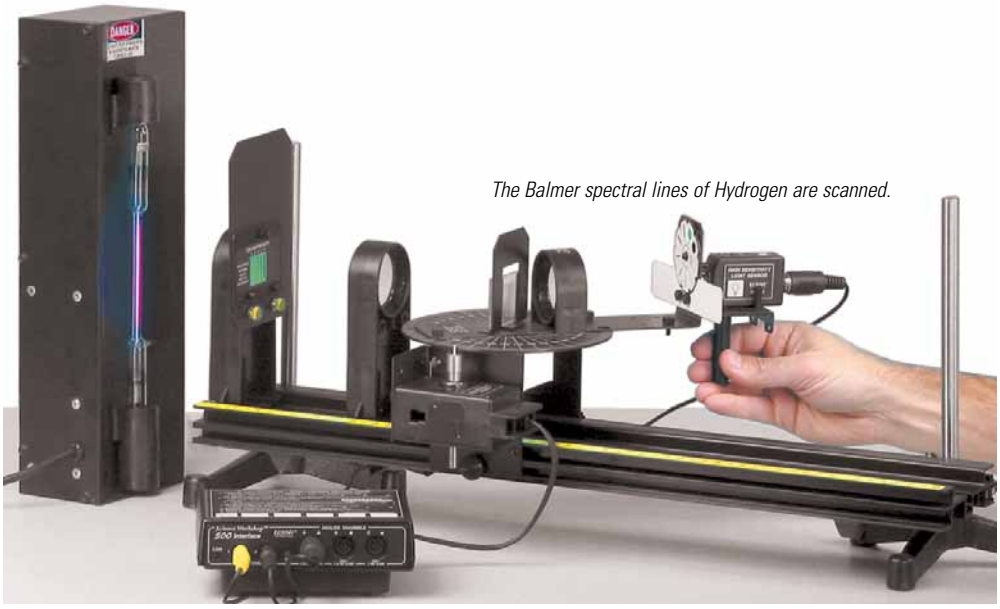
The wavelengths of the discrete lines of the atomic spectra of various gases are measured using a grating spectrophotometer.

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 spectrum of Sodium (the Sodium doublet cannot be resolved) is used to calibrate the diffraction grating.

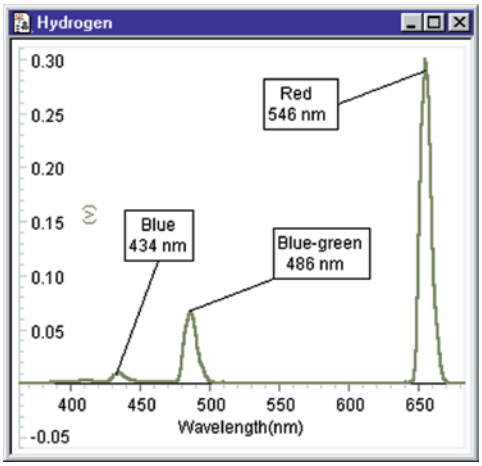
The wavelengths of the spectral lines are compared to the accepted values and, in the case of Hydrogen, the electron orbit transitions corresponding to the lines are identified.

PASCO Advantage

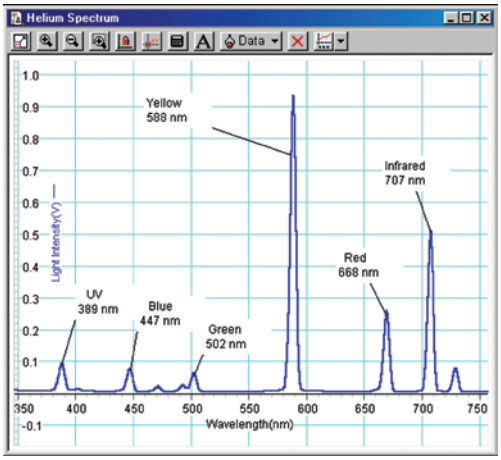
The open construction of the spectrophotometer allows the entire spectrum to be seen while the intensity versus angle is graphed in real-time.



The Balmer spectral lines of Hydrogen are scanned.



The three brightest lines of the Balmer series for Hydrogen. A scan with the Light Sensor set on a higher sensitivity reveals a violet line which cannot be seen in this scan.



Helium Spectrum

Experiment Includes:

	EX-9921 *ScienceWorkshop*	EX-9955 PASPORT
Spectrophotometer Accessory Kit	OS-8537	OS-8537
Optics Bench (60 cm)	OS-8541	OS-8541
Aperture Bracket	OS-8534A	OS-8534A
High Sensitivity Light Sensor	CI-6604	PS-2176
Rotary Motion Sensor	CI-6538	PS-2120
Small Round Base (2)	ME-8974	ME-8974
25 cm Steel Rod (2)	ME-8988	ME-8988
Low Pressure Sodium Light Source	OS-9287B	OS-9287B
Spectral Lamp Power Supply and Mount	SF-9288	SF-9288
Mercury Spectral lamp	SF-9282	SF-9282
Spectral Tube Power Supply and Mount	SE-9460	SE-9460
Hydrogen Spectral Tube	SE-9461	SE-9461
Helium Spectral Tube	SE-9462	SE-9462
Atomic Spectra Experiment Manual		
DataStudio Files for Atomic Spectra Experiment		
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