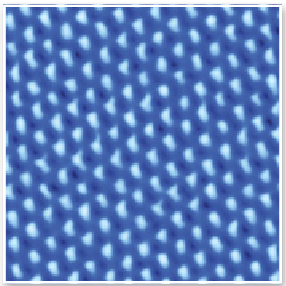
PREMIUM EXPERIMENTS

Nobel Prize-Worthy
Discoveries for Classrooms

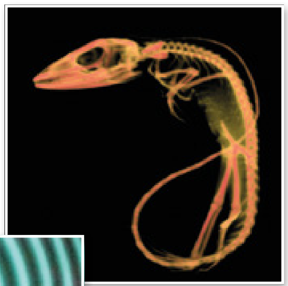
PHYWE

Experiments

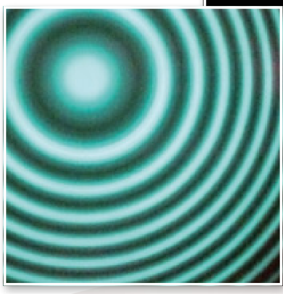
Discover the Wonders of Nobel Science with PHYWE



For over a century, the Nobel Prizes have symbolized groundbreaking discoveries and outstanding achievements in science. The laureates, through their profound knowledge and dedication, have shaped our modern understanding of the natural world and driven forward the frontiers of scientific knowledge. With PHYWE's Premium Experiments, you have the opportunity to delve into the fascinating world of these revolutionary discoveries and explore the principles behind the award-winning research in a hands-on and engaging way.



At PHYWE, we bring these Nobel Prize-worthy discoveries into classrooms and laboratories with our expertly designed experimental set-ups. Whether in physics, chemistry, biology, or medicine, our educational experiments allow complex scientific phenomena to be understood in an accessible and tangible manner. Students become active explorers, recreating the foundations and key concepts behind these monumental discoveries.



In this brochure, we present a selection of experiments inspired by the work of Nobel laureates and more premium experiments. Through practical, inquiry-based learning, students gain a deeper insight into scientific principles while experiencing firsthand the innovative spirit that drives great scientific minds.

Immerse yourself in the world of Nobel Prize-winning research – and discover the wonders of science in action!

Your PHYWE team

Follow in the Steps of Great Scientists with PHYWE

Nobel Prize in Physics 1901

Wilhelm Conrad Röntgen

"In recognition of the extraordinary services he has rendered by the discovery of the remarkable rays subsequently named after him"

X-ray Physics » Page 4

Nobel Prize in Physics 1918

Max Planck

"In recognition of the services he rendered to the advancement of Physics by his discovery of energy quanta"

Planck's "Quantum of Action" and External Photoelectric Effect » Page 12

Nobel Prize in Physics 1925

James Franck and Gustav Ludwig Hertz

"For their discovery of the laws governing the impact of an electron upon an atom"

Franck-Hertz Experiment » Page 10

Experience More than 50 Nobel Prize Awarded Experiments

1900 ...

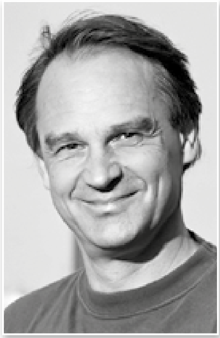
- **1901** **Wilhelm C. Röntgen**
- **1901** Jacobus H. van't Hoff
- **1902** Hendrik A. Lorentz, Pieter Zeeman
- **1903** Henri Becquerel, Pierre Curie, Marie Curie
- **1906** Joseph J. Thomson
- **1907** Albert A. Michelson
- **1908** Ernest Rutherford

1910 ...

- **1910** Johannes D. van der Waals
- **1911** Wilhelm Wien
- **1914** Max von Laue
- **1915** William H. Bragg, William L. Bragg
- **1917** Charles G. Barkla
- **1918** Fritz Haber
- **1918** **Max Planck**

1920 ...

- **1920** Walther H. Nernst
- **1921** Albert Einstein
- **1922** Niels H. D. Bohr
- **1923** Robert A. Millikan
- **1924** Karl M. G. Siegbahn
- **1924** Willem Einthoven
- **1925** **James Franck, Gustav L. Hertz**
- **1927** Arthur H. Compton
- **1927** Charles T. R. Wilson
- **1929** Louis V. P. R. de Broglie



Nobel Prize in Physics 1986

Heinrich Rohrer and Gerd Binnig

“For their design of the scanning tunneling microscope”

Nano Physics » Page 22

Nobel Prize in Physics 1943

Otto Stern

“For his contribution to the development of the molecular ray method and his discovery of the magnetic moment of the proton”

Stern-Gerlach Experiment » Page 11

Nobel Prize in Physics 2009

Charles Kuen Kao

“For groundbreaking achievements concerning the transmission of light in fibers for optical communication”

Fiber Optics » Page 25

1930 ...

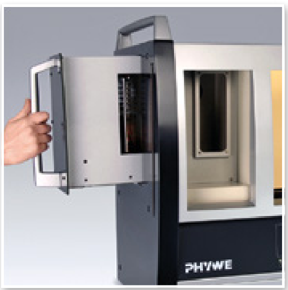
1930	Karl Landsteiner
1931	Carl Bosch, Friedrich Bergius
1932	Werner K. Heisenberg
1932	Irving Langmuir
1936	Victor F. Hess, Carl D. Anderson
1936	Petrus J. W. Debye
1937	Clinton J. Davisson, George P. Thomson

1940 ...

1943	**Otto Stern**
1945	Wolfgang E. Pauli
1948	Arne W. K. Tiselius
1952	Felix Bloch, Edward M. Purcell
1954	Max Born, Walther Bothe
1964	Charles H. Townes, Nikolay G. Basov, Alexander M. Prokhorov

1970 onwards

1971	Dennis Gabor
1979	Allan M. Cormack, Sir Godfrey N. Hounsfield
1985	Klaus von Klitzing
1986	**Heinrich Rohrer, Gerd Binnig**
2003	Paul C. Lauterbur, Sir Peter Mansfield
2009	**Charles K. Kao**
2009	Willard Boyle; George E. Smith



Tube XChange Technology

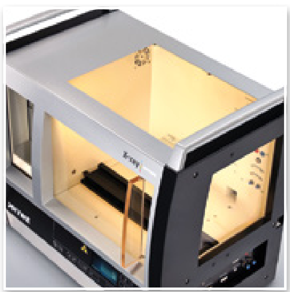
- Self-adjusting X-ray tubes with quick-change technology
- Contact protection against hot parts
- 4 anode materials for specific experiments (W, Mo, Cu, Fe)

Touch Panel

- Simultaneous control, manually and by computer
- Interactive, intuitive handling
- Self-explanatory icons for fast operation

High-Resolution TFT Backlit Display

- Diagonal 4,3", 480 × 272 pixels
- 16 bit, 65.536 colors
- With LED lighting
- Optimal, dynamic representation of all important device parameters and measured values



XXL Chamber

- Large space for large experiments
- Temperature-controlled, internally ventilated experimentation space

Insight Provides a Transparent View

- Exceptional Observability of the experimentation space
- Extra-large window front on 3 sides (diagonals: 18"/18"/14", 46 cm/46 cm/36 cm)

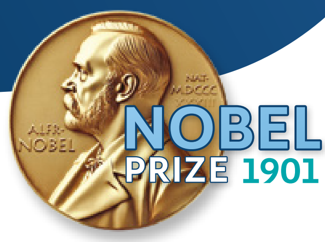
X-ray Physics

XR 4.0 Expert Unit – Made for Better Education

Discover the fascinating world of X-ray physics with our basic X-ray set! Whether it's exciting fluorescence experiments or stunning X-ray photography, the device offers everything you need to experience the fundamental principles up close. But that's just the beginning: for those eager to dive deeper, our topic-specific upgrade sets open up even more possibilities.

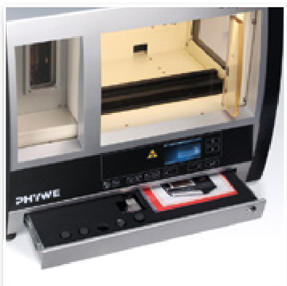
They cover a wide range of fields – from physics and chemistry to biology, medicine, materials science, and geosciences. Whether in school or atuniversity, our device is an essential tool for modern education and meets the highest safety standards.

Get inspired – for the science of tomorrow!



S-Lock:
New PHYWE Safety Interlock

- Electrical and mechanical safety lock
- Prevents door opening with switched on X-radiation
- Thus offers the highest possible safety



Goniometer (not pictured)

- Self-calibrating
- Collision protected
- Easy, safe handling

Safekeeping Drawer

- All accessories are kept safely and always ready at hand
- Lockable

XR 4.0 Expert Unit
Art. no. 09057-99

X-ray Upgrade Sets

Unlock New Potential for Advanced Insights and Exploration

Expand your exploration of X-ray physics with our XR 4.0 Upgrade Sets, crafted to provide deeper insights into a variety of scientific fields. Each set empowers learners and researchers alike to engage with advanced concepts through hands-on experiments, paving the way for innovative discoveries and a richer understanding of the world around us.

Upgrade Set: Solid-State Physics

Art. no. 09125-88

The "Solid-State Physics" upgrade set allows for in-depth investigations of the crystalline structure of solids through X-ray diffraction experiments. With this set, you can explore complex topics such as lattice constants and crystal structure analysis in a practical and engaging way.

Upgrade Set: X-ray Characteristics

Art. no. 09135-88

Our "X-ray Characteristics" upgrade set is used for the characterization of the radiation spectra of various different anode materials. It is particularly suitable for studying the fundamental principles of X-ray physics.

Upgrade Set: Material Analysis

Art. no. 09165-88

The "Material Analysis" upgrade set offers advanced tools for examining the elemental composition and properties of different materials through X-ray fluorescence and absorption techniques. This set allows for precise, non-destructive analysis, making it ideal for research in material science and engineering.

XR 4.0 Upgrade Sets

Upgrade Set: Structural Analysis

Art. no. 09145-88

Our “Structure Analysis” upgrade set enables detailed investigation of the atomic and molecular structures of materials using X-ray diffraction techniques. It is perfect for exploring crystallography and gaining insights into the internal arrangement of atoms in solids, essential for material science research.

Upgrade Set: Imaging

Art. no. 09155-88

The “Imaging” upgrade set allows for the visualization of internal structures of objects through X-ray imaging. This set is ideal for non-destructive testing and analysis, providing detailed insights into the hidden features of various materials and components.

Upgrade Set: Dosimetry

Art. no. 09175-88

Our “Dosimetry” upgrade set is particularly suitable for studying the dosimetry in qualitative and quantitative way. It enables the study of radiation doses, making it ideal for applications in medicine, radiology and biology.

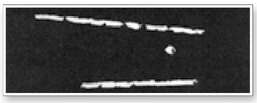
Upgrade Set: Computed Tomography

Art. no. 09185-88

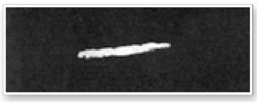
The “Computed Tomography” upgrade set allows for 3D imaging and detailed internal visualization of objects using X-ray technology.

This set is perfect for exploring non-destructive analysis techniques, providing comprehensive insights into the internal structure of various materials.

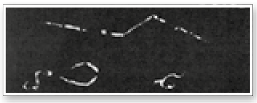
Background radiation:



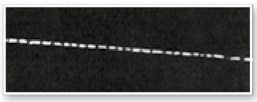
Proton



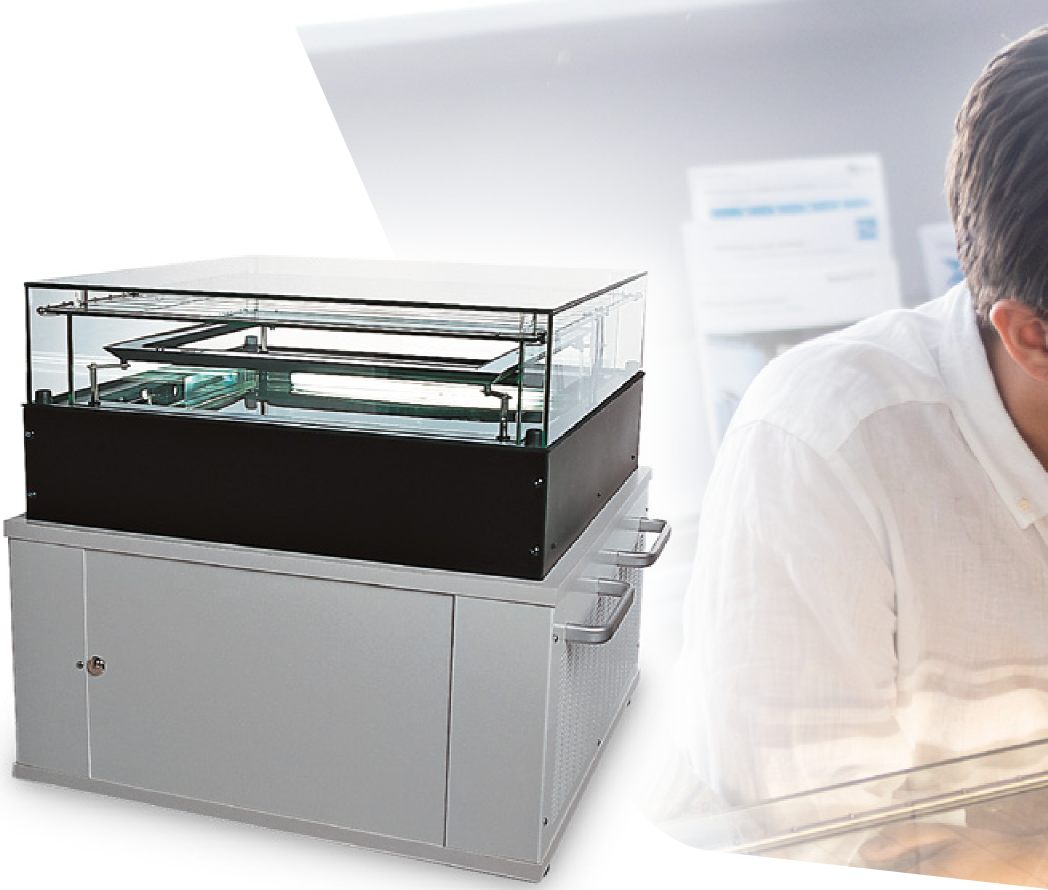
α-Particle



β-Particle



Meson



Small Diffusion Cloud Chamber

Diffusion Cloud Chamber

Invisible Becomes Visible – Observe the Tracks of Ionizing Radiation

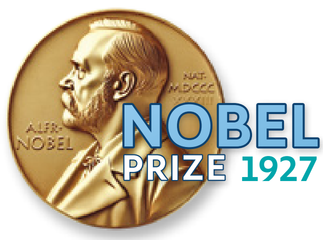
PHYWE's diffusion cloud chambers are suitable for observing natural ionizing radiation: cosmic radiation and the natural radioactivity of the earth. The ever-changing patterns of both types of natural radiation can be observed simultaneously thanks to the large observation area.

When a charged particle (like an *α*- or *β*-particle) passes through the chamber, it ionizes the surrounding gas. The vapor condenses around these ionized particles, forming tiny droplets that trace the particle's path. These visible trails reveal the motion and interaction of subatomic particles, providing insight into radiation and particle physics. The diffusion cloud chamber offers the opportunity to carry out physical experiments with the aid of artificial radiation sources.

- Perfect for walk-around displays in science centers
- Only instrument to visualize charged particles (beta) and cosmic radiation (mesons, myons)
- Easy differentiation between *α*-particle, *β*-particle, protons, myons, electrons and positrons

LEARNING OBJECTIVES

- Natural Radioactivity
- Cosmic Radiation
- Ionising Particles, Mesons
- Radioactive Decay
- Lorentz Force



Large Diffusion Cloud Chamber, 80 × 80 cm
Art. no. 09043-93

Small Diffusion Cloud Chamber, 45 × 45 cm
Art. no. 09046-93

Single Photon Counter MiniPIX

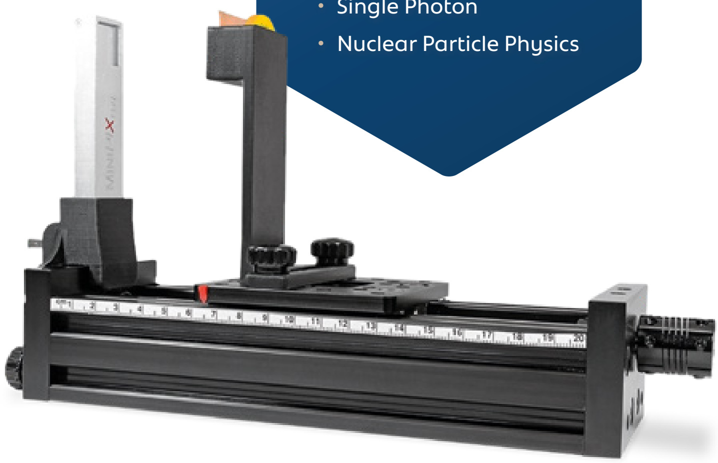
Tracking the Tiny –
Unraveling Particle Paths with MiniPIX

The MiniPIX single photon counter is a compact particle detector that uses a pixelated semi-conductor sensor to detect individual photons or charged particles. Each pixel in the sensor is capable of counting and recording the energy deposited by incoming particles, allowing precise detection at a very high resolution. MiniPIX can distinguish between different types of radiation (such as X-rays, γ-radiation, or α- and β-particles) based on their energy levels.

This makes it highly useful in fields like radiation monitoring, medical imaging, and particle physics, where precise detection and imaging of ionizing radiation is essential.

LEARNING OBJECTIVES

- Particle Detection
- Energy Measurement
- Radiation
- Single Photon
- Nuclear Particle Physics



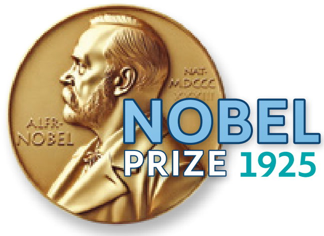
Single Photon Counter MiniPIX
Art. no. 09075-00

Franck-Hertz Experiment

Impact of an Electron upon an Atom

The Franck-Hertz experiment is a key milestone in quantum physics, demonstrating the existence of discrete energy states in atoms. This experiment makes it possible to visualize quantized energy transitions through electron collisions.

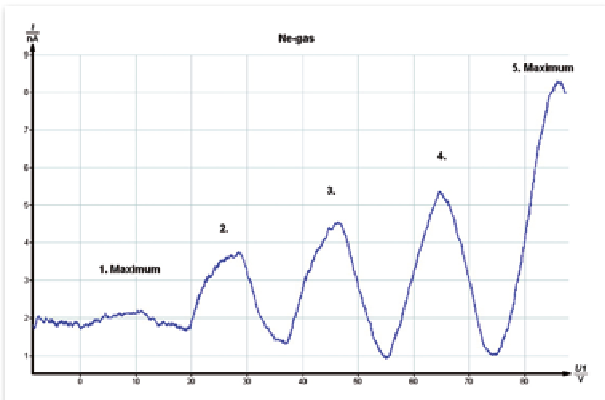
At PHYWE, we offer both the classic version with a mercury tube and a modern alternative with neon. The neon atoms emit light as they return to their ground state, producing visible spectral lines. Both versions allow for the exploration of fundamental principles of atomic physics and the behavior of electrons at different energy levels—perfect for educational use in schools and universities.



Franck-Hertz experiment
with Ne-tube

LEARNING OBJECTIVES

- Quantization of Atomic Energy Levels
- Electron-Atom Collisions
- Inelastic Electron Collisions
- Excitation Energy
- Energy Transitions



Example of a Franck-Hertz curve for Ne-gas

Franck-Hertz Experiment with a Hg-Tube
Art. no. P2510311

Franck-Hertz Experiment with a Ne-Tube
Art. no. P2510315

Stern-Gerlach Experiment

Retrace the First Proof of Quantisation of the Angular Momentum of an Atom

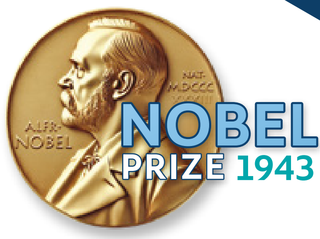
A beam of potassium atoms generated in a hot furnace travels along a specific path in a magnetic two-wire field. Because of the magnetic moment of the potassium atoms, the non-homogeneity of the field applies a force at right angles to the direction of their motion.

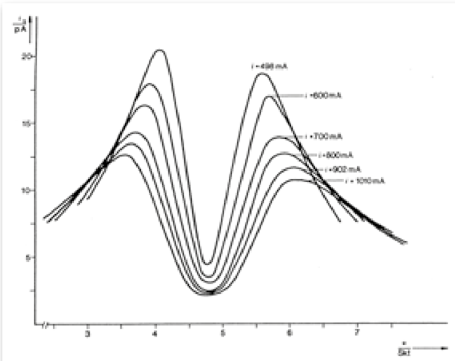
The potassium atoms are thereby deflected from their path. By measuring the density of the beam of particles in a plane of detection lying behind the magnetic field, it is possible to draw conclusions as to the magnitude and direction of the magnetic moment of the potassium atoms.

LEARNING OBJECTIVES

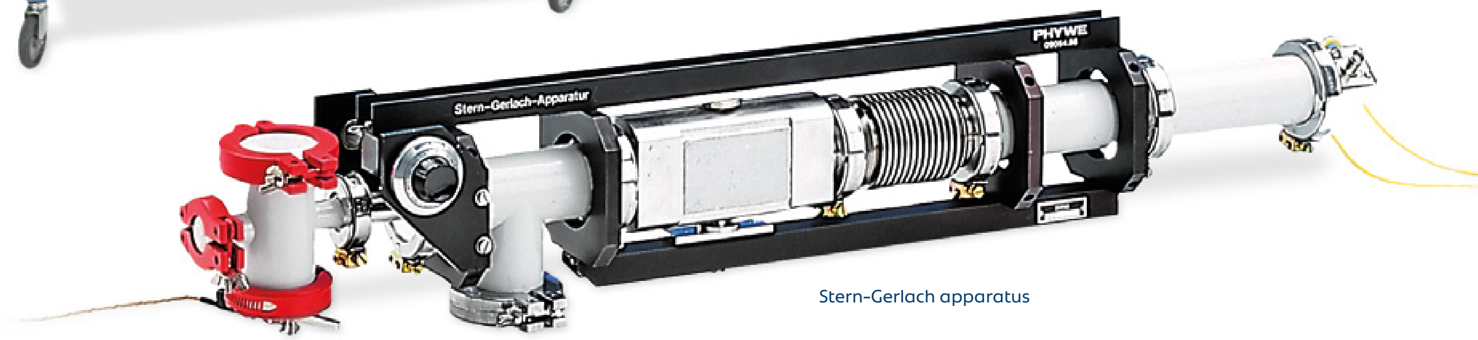
- Quantization of Angular Momentum
- Spin and Magnetic Moments
- Spatial Quantization
- Bohr Magneton
- Atomic Beam

Stern-Gerlach experiment setup





Ionization current as a function of position (u) of detector with large excitation currents in the magnetic analyser

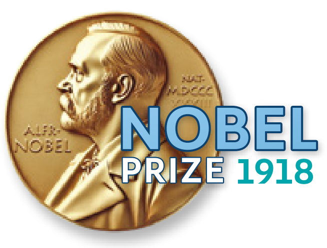


Stern-Gerlach apparatus

Stern-Gerlach Experiment
Art. no. P2511101

LEARNING OBJECTIVES

- Quantization of Light Energy and Photons
- External Photoelectric Effect in Quantum Theory
- Measurement of Planck's Constant
- Photon Energy
- Absorption



Planck's "Quantum of Action" and External Photoelectric Effect

Foundations of Quantum Physics

These experiments provide a clear demonstration of fundamental quantum physics concepts, particularly the quantized nature of light and the transfer of energy through photons. Both versions aim to investigate Planck's quantum of action and the external photoelectric effect, using different methods to separate spectral lines.

In the first version, interference filters are used to selectively isolate specific wavelengths of light, allowing precise measurement of photon energy. This method provides an accurate study of quantized energy transfer in the photoelectric effect. In the second version, spectral lines are separated using a diffraction grating. This alternative approach effectively demonstrates the splitting of light into its component wavelengths, enabling a detailed analysis of the photoelectric effect and the calculation of Planck's constant.

Both approaches offer valuable insights into quantum mechanics and illustrate how light transfers energy to electrons in the form of photons, a phenomenon that significantly contributed to the development of modern physics.

Planck's "Quantum of Action" and Photoelectric Effect (Line Separation by Interference Filters)
Art. no. P2510402

Planck's "Quantum of Action" and External Photoelectric Effect
Art. no. P2510511

LEARNING OBJECTIVES

- Semiconductors
- Band Theory
- Intrinsic and Extrinsic Conductivity
- Magnetic Resistance
- Hall Coefficient

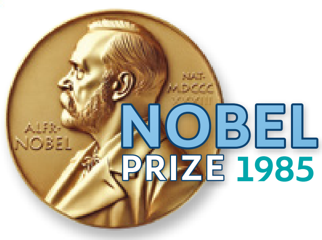
Hall Effect in n- and p-Germanium

Solid-State and Semiconductor Physics

The Hall Effect experiment demonstrates the behavior of electric charges in a conductor or semiconductor when exposed to a magnetic field.

In the experiment, a current is passed through a thin strip of material, and a perpendicular magnetic field is applied. This causes the moving charge carriers (electrons or holes) to experience a force, known as the Lorentz force, which deflects them to one side of the material. As a result, a voltage difference, called the Hall Voltage, develops across the sides of the strip.

This Hall voltage is proportional to the magnetic field strength and helps determine properties like the type of charge carriers and their concentration in the material.



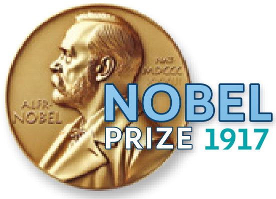
Hall Effect in n- and p-Germanium (with the Teslameter)
Art. no. P2530102

Hall Effect in n- and p-Germanium (PC)
Art. no. P2530116

LEARNING OBJECTIVES

- Photoelectric Effect
- Shell Structure of Electron Shells
- Characteristic X-Ray Radiation
- γ-spectrometry
- X-Ray Spectral Analysis

X-Ray Fluorescence and Moseley's Law



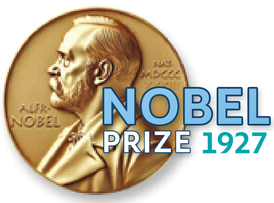
Learn about Moseley's Contribution to Understanding the Atom

The irradiation of iodine, barium (sulfat), silver and tin with soft γ-radiations gives rise to K_α radiations characteristics of these elements.

The X-ray spectra are recorded with a γ-spectrometer consisting of a scintillation counter, a pulse height analyser and a recorder. After calibration of the spectrometer, the Rydberg constant is determined from the energies of the X-ray lines, using Moseley's law.

X-Ray Fluorescence and Moseley's Law
Art. no. P2524715

Compton Effect



When Photons Collide: Unveiling Quantum Behavior

When photons e.g. γ-radiation collide with electrons in a material, they transfer some of their energy to the electrons, causing the photons to scatter at different angles. The scattered photons have a longer wavelength (lower energy) compared to the incoming photons. This change in wavelength, called the Compton Shift, can be determined and it depends on the scattering angle.

The experiment confirmed that light behaves as photons with quantized energy, supporting quantum theory and provides evidence for the dual nature of electromagnetic radiation.

LEARNING OBJECTIVES

- Corpuscle
- Scattering
- Compton Wavelength
- De Broglie Wavelength
- Klein-Nishina Formula

Compton Effect with the Multichannel Analyser
Art. no. P2524415

Zeeman Effect

Unveiling Magnetic Fields, Unlocking Quantum Worlds

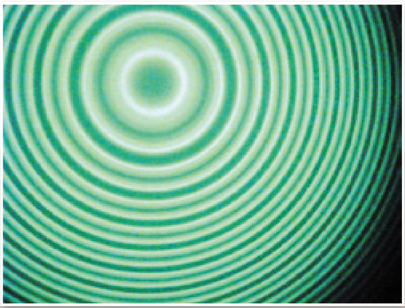
The "Zeeman Effect" is the splitting up of the spectral lines of atoms within a magnetic field. The simplest is the splitting up of one spectral line into three components called the "normal Zeeman effect".

In this experiment the normal Zeeman effect as well as the anomalous Zeeman effect are studied using a cadmium spectral lamp as a specimen. The cadmium lamp is submitted to different magnetic flux densities and the splitting up of the cadmium lines is investigated using a Fabry-Perot interferometer. The evaluation of the results leads to a precise value for Bohr's magneton.

This experiment is also available with an electromagnet.

LEARNING OBJECTIVES

- Bohr's Atomic Model and Bohr's Magneton
- Quantisation of Energy Levels
- Electron Spin
- Interference of Electromagnetic Waves
- Fabry-Perot Interferometer



Interference rings with the anomalous Zeeman Effect

Zeeman Effect with a Variable Magnetic System
Art. no. P2511010

Zeeman Effect with Electromagnet
Art. no. P2511009

Quantum Eraser

Erasing Boundaries in Quantum Physics

The quantum eraser experiment demonstrates how observation affects quantum behavior. When photons pass through a double slit, they form an interference pattern, showing wave-like behavior. If the "which-path" information is known, the interference disappears, revealing particle-like behavior. However, by "erasing" this information using entangled photons, the interference pattern returns, showing that the act of observation influences the outcome, even retroactively.

LEARNING OBJECTIVES

- Quantum Mechanics
- Wave particle Duality
- Inteference Patterns
- Quantum Entanglement Principles
- „Which-Path" Information vs. Interference

Quantum Eraser
Art. no. P2220811

LEARNING OBJECTIVES

- Principles of Interference and Superpostition
- Wavelength of Light
- Optical Path Difference and Coherence
- Application of Inter-ferometry in Precise Measurements
- Speed of Light

Michelson Interferometer

Exploring Wave Interference

The Michelson interferometer experiment measures precise length changes by exploiting interference. A beam of light is split into two perpendicular paths using a beam splitter. Each beam reflects off mirrors and then recombines at the beam splitter. The combined light creates an interference pattern, which shifts if there are changes in the path lengths.

By analyzing these shifts, the interferometer can detect minute changes in distance or measure wavelength differences with high precision. This technique is widely used in various applications, including gravitational wave detection and optical measurements.

Michelson Interferometer – High Resolution
Art. no. P2220911

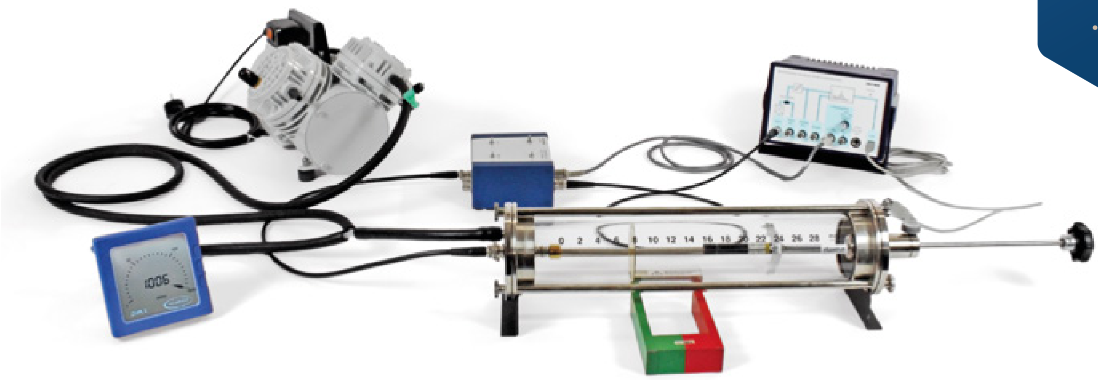
Rutherford Experiment

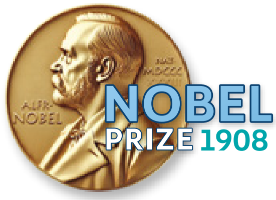
Unlocking the Secrets of the Atomic Nucleus

The Rutherford gold foil experiment is part of a landmark series of experiments by which scientists discovered that every atom contains a nucleus where its positive charge and most of its mass are concentrated. In order to obtain maximum possible counting rates, the Chadwick Geometry is used where the scattering angle is varied over a wide range by moving foil and source.

LEARNING OBJECTIVES

- Scattering Experiment
- Rutherford Atomic Model
- Scattering Angles
- Coulomb Field
- Nuclear Structure





Rutherford Experiment
Art. no. P2522115

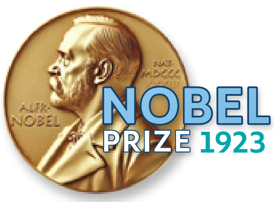
LEARNING OBJECTIVES

- Electric Field
- Viscosity
- Stokes' Law
- Droplet Method
- Electron Charge

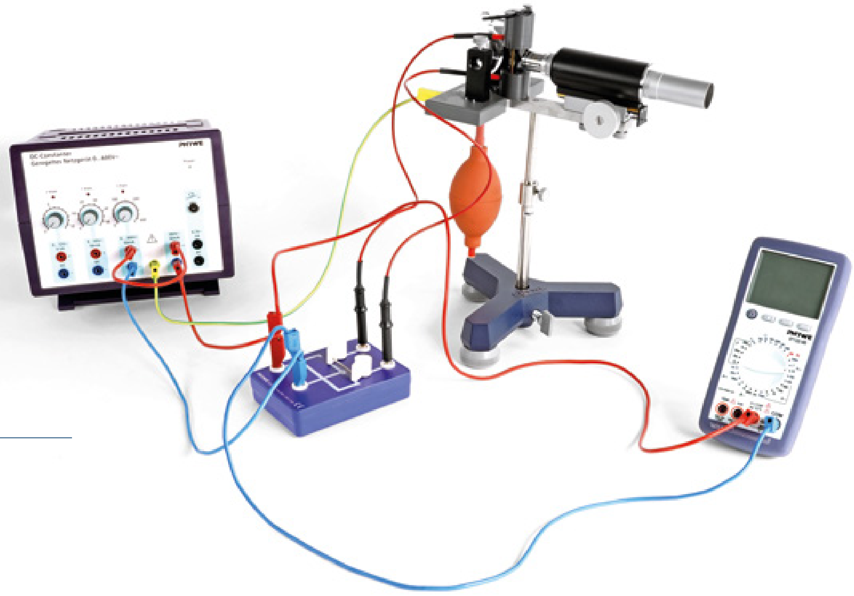
Elementary Charge and Millikan Experiment

Measuring the Fundamental Unit of Charge

Charged oil droplets subjected to an electric field and to gravity between the plates of a capacitor are accelerated by application of a voltage. The elementary charge is determined from the velocities in the direction of gravity and in the opposite direction.



Elementary Charge and Millikan Experiment
Art. no. P2510100



Specific Charge of the Electron – e/m

Understanding Electrons in Electric and Magnetic Fields

LEARNING OBJECTIVES

- Cathode Rays
- Lorentz Force
- Electron in Crossed Fields
- Electron Mass
- Electron Charge

The experiment to determine the specific charge of the electron (e/m) measures the ratio of the electron's charge (e) to its mass (m). In this experiment, electrons are accelerated through an electric field and then pass through a magnetic field. The magnetic field causes the electrons to travel in a circular path. By measuring the radius of this path and knowing the magnetic field strength, the velocity of the electrons can be determined.

Using these measurements, the specific charge can be calculated. This experiment provides fundamental insights into the properties of electrons and is crucial for understanding atomic and particle physics.

Specific Charge of the Electron – e/m
Art. no. P2510200

LEARNING OBJECTIVES

- Coulomb's Law and Electrostatic Interactions
- Coulomb Potential
- Electric Field
- Charge Distribution
- Image Charge

Coulomb Potential and Coulomb Field of Metal Spheres

Analyzing Electrostatic Interactions and Charge Distribution

The Coulomb Potential experiment involves charging conducting spheres of different diameters and measuring their electric fields and potentials Using an electric field meter equipped with a potential measuring probe, the static electric potentials and field intensities are determined as functions of position and voltage.

The experiment is computer-assisted, allowing precise measurements of how the electric potential varies with distance from the charged spheres and how it relates to the applied voltage. This setup demonstrates the principles of Coulomb's Law, showing how electric potential and field strength depend on the charge and size of the conducting spheres.

Discover curricuLAB®

Check out our digital descriptions for all our experiments:
Explore comprehensive information and interactive elements that enhance your understanding!

Coulomb Potential and Coulomb Field of Metal Spheres
Art. no. P2420505

Magnetic Resonance Tomograph (MRT)

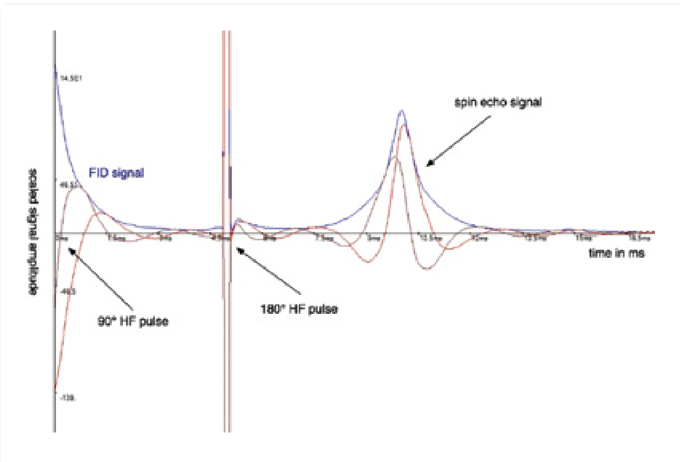
The Power of Advanced Imaging Technology in a Space-Saving Design for Education

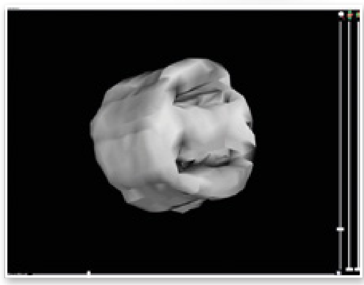
Fully functional Magnetic Resonance Tomograph (MRT) for teaching purposes, covering all aspects from the basic principles of Nuclear Magnetic Resonance (NMR) to the high-resolution 2D and 3D MR imaging (MRI). The system gives you the unique opportunity of offering training at a real MRT machine in the student lab. In order to provide for realistic and practice-oriented nuclear magnetic resonance (NMR) training for all fields of science and medicine.

The training software makes it easy for the users to experience all aspects of magnetic resonance tomography. The following imaging procedures can be performed: spin-echo 2D, flash 2D, localized spin echo 2D, spin echo 3D.

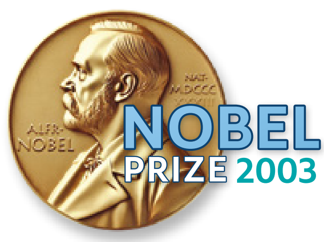
LEARNING OBJECTIVES

- Nuclear Spins; Atomic Nuclei with a Magnetic Moment
- Precession of Nuclear Spins; Magnetisation
- Resonance Condition, MR Frequency
- FID Signal (Free Induction Decay)
- Spin Echo





Spin echo signal of an oil sample occuring 10 ms (echo time) after a 90° HF pulse (FID signal is shown).

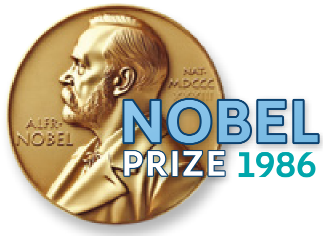


Compact MRT (Magnetic Resonance Tomography)
Art. no. 09500-99

Scanning Tunneling Microscope (STM)

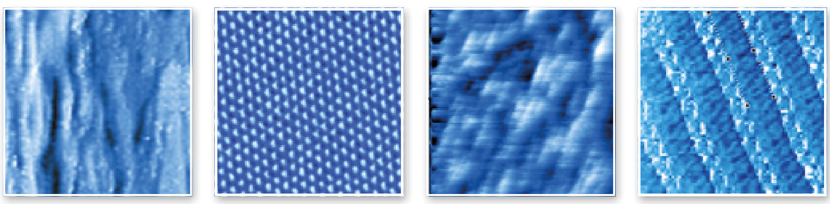
Discover the World of Nano Physics – Atomic Resolution of the Graphite Surface

Approaching a very sharp metal tip to an electrically conductive sample by applying an electrical field leads to a current between tip and sample without any mechanical contact. This so-called tunneling current is used to investigate the electronic topography on the sub-nanometer scale of a fresh prepared graphite (HOPG) surface. By scanning the tip line-by-line across the surface graphite atoms and the hexagonal structure are imaged.



LEARNING OBJECTIVES

- Tunneling Effect
- Imaging on the Sub-Nanometer Scale
- Piezo-Electric Devices
- Local Density of States (LDOS)
- Hexagonal Structures



Microstructures

Atomic Resolution of the Graphite Surface by STM (Scanning Tunneling Microscope)
Art. no. P2532000

Atomic Force Microscope (AFM)

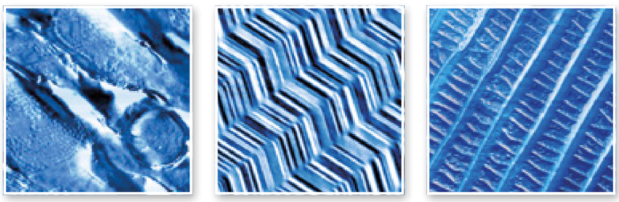
Visualize and Image Microstructures

The PHYWE Compact Atomic Force Microscope (AFM) is a cutting-edge tool designed for educational and research environments, bringing the power of nanoscale imaging and measurement to your laboratory. Utilizing advanced AFM technology, this compact instrument allows users to explore surface topography and mechanical properties with exceptional resolution.

With its user-friendly interface, the PHYWE Compact AFM is ideal for both students and researchers. It provides hands-on experience in nanoscale analysis, fostering a deeper understanding of material science, physics, and biology. Its portability makes it perfect for educational institutions, enabling the integration of advanced microscopy techniques into the curriculum without the need for bulky equipment.

LEARNING OBJECTIVES

- Static Mode, Dynamic Mode
- Imaging on the Micrometer Scale
- Lennard-Jones Potential
- Magnetic Force Microscopy
- Phase Contrast Imaging



Microstructures

Compact AFM (Atomic Force Microscope)
Art. no. 09700-99

Ripple Tank

Visualizing Water Wave Phenomena in a Dynamic Learning Environment

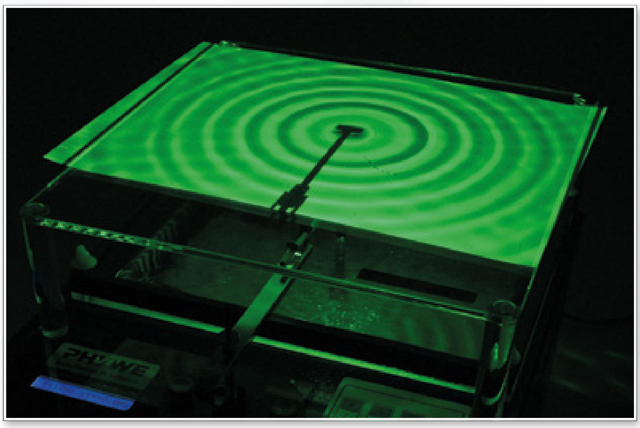
Easy to operate: just switch on the instrument, add water and start! The PHYWE ripple tank is an easy to use, virtually soundless and compact device which allows demonstrative and quantitative access to wave mechanics principles.

The frequency range of 5 to 60 Hz with variable amplitudes covers all necessary frequencies to perform demonstration and lab course experiments both at schools and universities.

With the PHYWE Ripple tank you can realize qualitative and quantitative results within a very short time. With the optional available external vibration generator (article no. 11260-10) it is possible to demonstrate interference phenomena or the Doppler effect.

LEARNING OBJECTIVES

- Principles of Wave Behavior
- Reflection, Refraction and Diffraction
- Wave Interactions and Interference Patterns
- Wavelength, Frequency and Wave Speed
- Doppler Effect



PHYWE Ripple Tank with LED Light Source, Complete Set
Art. no. 11260-88

Measuring the Velocity of Light

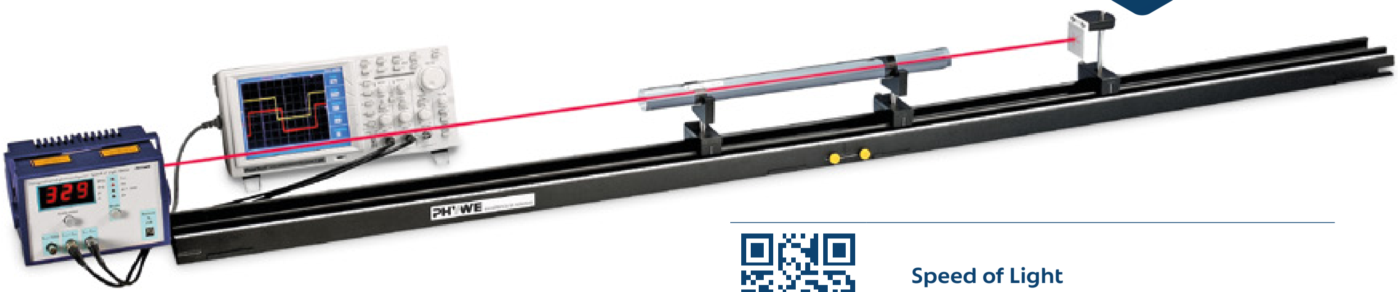
Investigating a Fundamental Constant in Physics

PHYWE's experiment for measuring the speed of light allows students to explore this essential constant using a coherent light source and advanced measurement devices.

Participants accurately determine the speed of light through various media, demonstrating its significance in modern physics and technologies like telecommunications and GPS. This hands-on experience fosters critical thinking and practical skills while enhancing appreciation for the scientific process.

LEARNING OBJECTIVES

- Principles of Light Propagation
- Refractive Index
- Wavelength, Frequency and Phase Modulation
- Electric Field Constant
- Magnetic Field Constant



Speed of Light
Art. no. P2210101

Fiber Optics

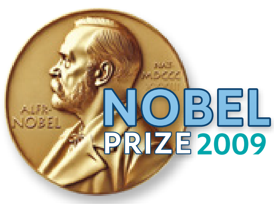
Illuminating Connectivity with Fiber Optics

The fiber optics experiment demonstrates total reflection in optical fibers. A laser diode beam is coupled into a monomode fiber, and the challenges of this coupling are evaluated.

A low-frequency signal is transmitted, and the fiber's numerical aperture is recorded. The transit time of light is measured to determine its velocity, while measuring the diode laser's output power relative to supply current reveals its "threshold energy" and "slope efficiency."

LEARNING OBJECTIVES

- Total Reflection
- Gaussian Beam
- Monomode and Multimode Fibre
- Velocity of Light
- Transverse and Longitudinal Modes



Fiber Optics
Art. no. P2261000

Helium-Neon Laser

Inside the Beam: The Helium-Neon Laser Revealed

The helium-neon (He-Ne) laser experiment demonstrates the principle of laser operation using a gas mixture of helium and neon. In this setup, an electric current excites helium atoms, which then transfer energy to neon atoms through collisions.

The neon atoms, in an excited state, emit photons when they return to a lower energy level. These photons stimulate other excited neon atoms to emit more photons, creating a coherent beam of light.

The laser's optical cavity, composed of two mirrors, amplifies and directs this beam, producing a highly focused and monochromatic light beam. This experiment illustrates the fundamentals of laser technology, including spontaneous and stimulated emission and optical amplification.

Helium-Neon Laser
Art. no. P2260701

LEARNING OBJECTIVES

- Spontaneous and Stimulated Light Emission
- Resonator Cavity
- Gas Discharge Tube
- Collision of Second Type
- Brewster Angle

LEARNING OBJECTIVES

- Thermal Tension Coefficient
- General Equation of State for Ideal Gases
- Universal Gas Constant
- Amontons' Law
- Relation between Temperature, Pressure and Volume

Equation of State for Ideal Gases (Gas Laws: Gay-Lussac, Amontons, Boyle)

Demonstrate the Temperature and the Kinetic Theory of Gases

The state of a gas is determined by temperature, pressure and volume. For the limiting case of ideal gases, these state variables are linked via the general equation of state. For a change of state under isochoric conditions this equation becomes Amontons' Law.

In this experiment it is investigated whether Amontons' Law is valid for a constant amount of gas (air). With this compact experiment setup all three gas laws can be performed. The experiment provides a simplified model that helps to predict the behavior of gases under various conditions.

Equation of State for Ideal Gases (Gas Laws: Gay-Lussac, Amontons, Boyle)
Art. no. P2320167

Maxwell-Boltzmann Velocity Distribution

Understanding Particle Motion in Gases

LEARNING OBJECTIVES

- Kinetic Theory of Gases
- Kinetic Energy
- Average Velocity
- Gas Molecules
- Velocity Distribution

By means of the model apparatus for kinetic theory of gases the motion of gas molecules is simulated and the velocities determined by registration of the throw distance of the glass balls.

This velocity distribution is compared to the theoretical Maxwell-Boltzmann equation.

Maxwell-Boltzmann Velocity Distribution
Art. no. P2320300

Heat Capacity of Metals

Exploring Thermal Properties and Energy Storage

The experiment on the heat capacity of metals using the Cobra SmartSense system allows students to explore the thermal properties of various metals.

Students measure how different metals respond to heat, determining their specific heat capacities and understanding their ability to absorb and store thermal energy.

LEARNING OBJECTIVES

- Mixture Temperature
- Boiling Point
- Dulong Petit's Law
- Internal Energy
- Debye Temperature

Heat Capacity of Metals with Cobra SMARTsense
Art. no. P2330167

RLC Circuit

Exploring Resonance, Impedance, and Energy Storage in Electrical Systems

The PHYWE RLC circuit experiment provides a detailed exploration of the principles governing electrical circuits containing resistors (R), inductors (L), and capacitors (C). This hands-on experiment enables students to analyze the behavior of RLC circuits in both series and parallel configurations, focusing on key concepts such as resonance, impedance, and energy storage.

Students will connect circuit components and utilize measurement tools to observe the effects of varying frequencies on voltage and current. By studying the phase relationships between voltage and current in different circuit configurations, students gain insight into the reactive nature of inductors and capacitors and how they influence circuit dynamics.

LEARNING OBJECTIVES

- Fundamentals of RLC Circuits
- Resonance Phenomena
- Impedance
- Voltage and Current Phase Relationsips
- Circuit Assembly

RLC Circuit
Art. no. P2440601

Stirling Engine

Visualization of a Carnot-Process

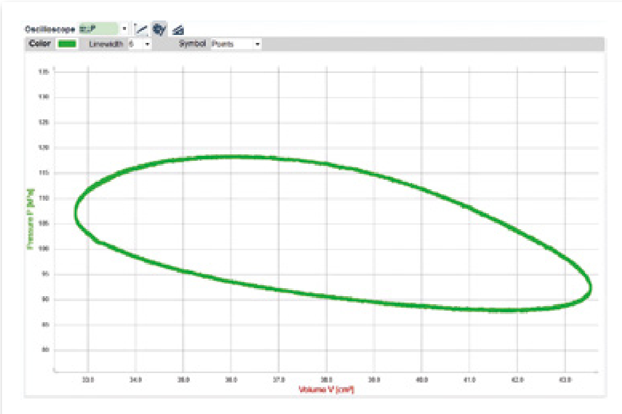
The Stirling Engine experiment using digital data acquisition provides an engaging way to explore thermodynamic principles and heat engines. Students observe the operation of a Stirling Engine, which converts thermal energy into mechanical work through the cyclic compression and expansion of gas.

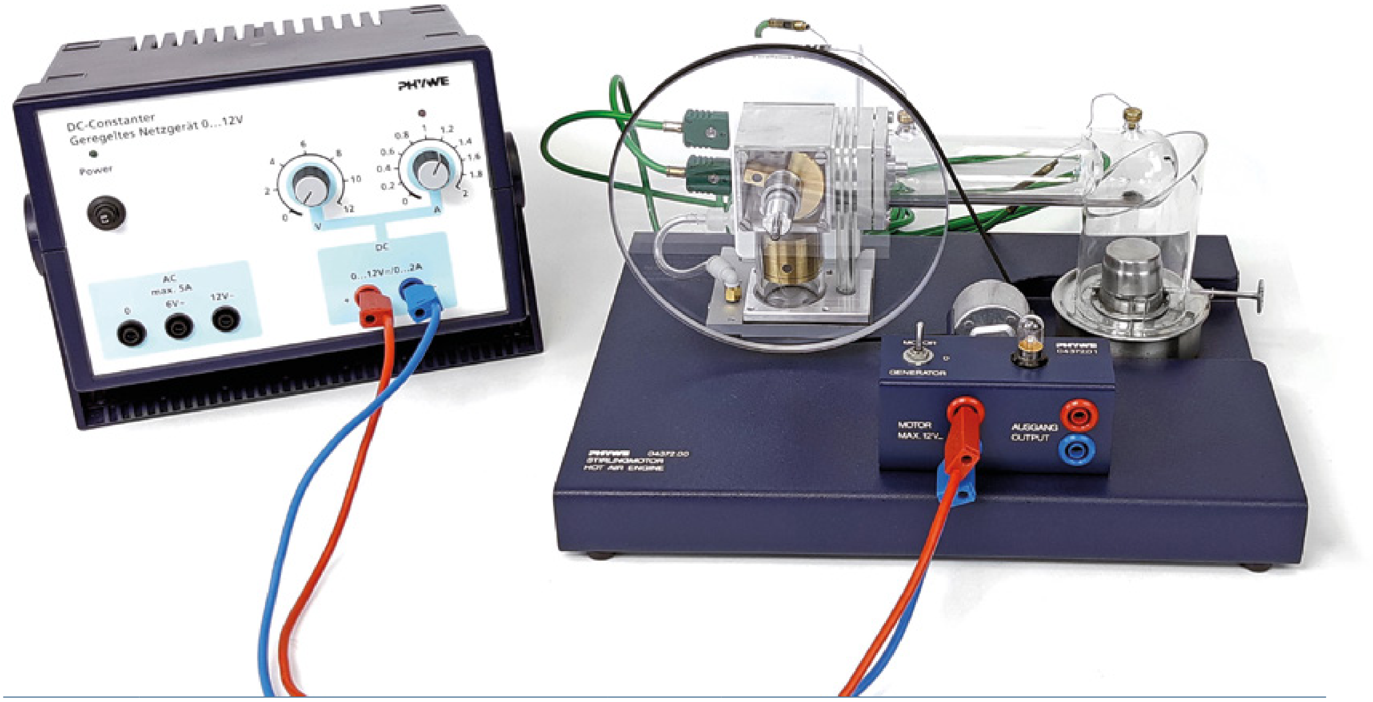
The students capture real-time data on temperature changes and engine performance, gaining insights into the engine's efficiency and functionality. This hands-on experience enhances their understanding of heat transfer and energy conversion while developing practical skills in data collection and analysis.

The experiment effectively combines classic thermo-dynamics with modern measurement techniques, making it an excellent educational tool.

LEARNING OBJECTIVES

- First and Secondary Law of Thermodynamics
- Reversible Cycles
- Isochoric and Isothermal Changes
- Efficiency
- Conversion of Heat





Stirling Engine with measureLAB
Art. no. P2360467

LEARNING OBJECTIVES

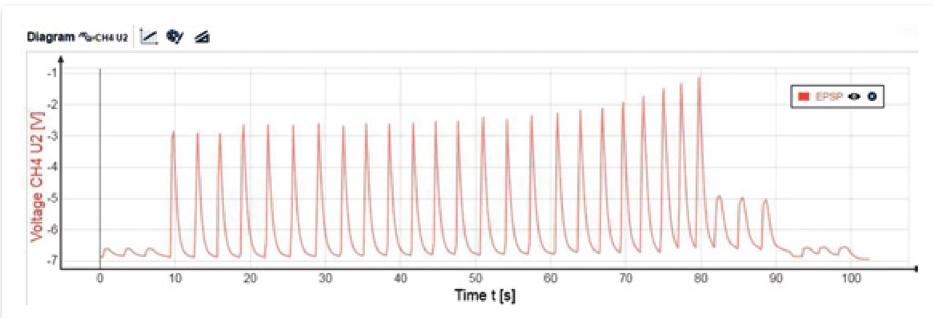
- Action Potential
- Different Types of Synapses
- Synaptic Learning and Forgetting
- Conditioned Reflex
- Motoneuron

Nerve Cell Interactions

Learn about Nerve Cells and how they Work Together

The experiment on the interaction of nerve cells provides an engaging way to study neurobiology and the signaling mechanisms between nerve cells. Students can observe and analyze electrical activity, measuring action potentials and synaptic responses in real time.

This hands-on experience enhances the understanding of neuronal communication while developing practical skills in electrophysiology. The integration of modern technology with neurobiological concepts makes this experiment an effective educational tool.



Measurement of conditioned reflex

Nerve Cell Interactions with Cobra SMARTsense
Art. no. P4010869

Innovating Education

Our Commitment to Excellence

With over a century of experience, PHYWE leads in science education, offering customized solutions for educators worldwide. Based in Germany, our integrated approach promotes engaging and effective scientific learning.

Focused on quality and sustainability, we collaborate with over 110 organizations in 120 countries to empower learners and teachers. Our didactic systems are designed with educators to fit diverse curricula.

Empowering Learning

Through LNEG, the Lucas-Nülle Education Group

The Lucas-Nülle Education Group, including Lucas-Nülle and PHYWE, offers comprehensive education solutions. We create unique didactic systems for schools and vocational training, providing flexible options for institutions from primary schools to technical universities. Committed to respect, integrity, and social responsibility, we deliver high-quality educational experiences tailored to learners' needs.

Transforming Knowledge into Action

With Real Experience Learning (RXL)

Active engagement is essential for true learning. By connecting the didactic solutions of Lucas Nülle and PHYWE, our hands-on methodology Real Experience Learning helps learners develop practical skills. This integration of theory and practice empowers students to grasp and apply scientific concepts, preparing them for future challenges.

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Our Solutions for More Customer Satisfaction

Service | PHYWE

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- International training weeks

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- Online webinars
- YouTube product videos (pre-sales/after-sales)

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- Curricula-based quotations
- Online orders
- Project planning, tender support
- Product introduction seminars
- Newsletters

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- Turn-key project management
- Warranty, repairs and spare parts
- Follow-up trainings

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