TESS expert PHYWE

Demo expert PHYWE

Eng

Geo

JAN. 2013

Engineering/Geo Science

University Experiments

PHYWE excellence in science

Materials Science and Engineering: Curricula Compliant Experiments –

for your educational needs

PHYWE™ experiments have been matched to the curricula of more than 30 selected universities worldwide. The interaction between PHYWE's experiments and the supporting content of experimental lectures and lab courses has led to the creation of a teaching package that is highly relevant to the curriculum worldwide.

Materials Science and Engineering

Bachelor of Science Course – Reference Curriculum

Content	1. Sem.	2. Sem.	3. Sem.	4. Sem.	5. Sem.	6. Sem.
Laboratory Experiments	General Physics*		Electrical Engineering (Chapter 5)		Material Analysis and Testing (e.g. NDT) (Chapter 4)	
	General and Inorganic Chemistry**		Physical Chemistry**	Crystallography (Chapter 3)	Thermo-chemistry**	
		Materials Science 1 (Chapter 3)	Materials Science 2 (Chapter 3)			
Lecture, Tutorial, Experiments	General Physics*		Electrical Engineering (Chapter 5)		Solid State Physics*	
	Materials Science 1 (Chapter 3)		Materials Science 2 (Chapter 3)		Material Analysis and Testing (e.g. NDT) (Chapter 4)	
	General and Inorganic Chemistry**		Physical Chemistry**	Organic Chemistry**	Electrochemistry**	
			Crystallography (Chapter 3)		Thermo-chemistry**	
Elective Subject			e.g. Metals, Polymers, Ceramics, Biomaterials		e.g. Nanotech., Renew. Energy, Electr. Devices, Photonics (Chap. 5,6,7)	
Theoretical Courses	Mathematics		Computer Sciences and Engineering		Measurement Technology	
			Technical Mechanics		Design and Construction	Business Administration and Industrial Management
Interships			Industrial Intership		Research Intership	
Bachelor Thesis						Bachelor Thesis

More than 80% of the experimental courses are covered by PHYWE experiments!

PHYWE Experiments available in this catalogue

* Please refer to TESS expert Physics catalogue

** Please refer to TESS expert Chemistry catalogue

Geo Science: Curricula Compliant Experiments –

multidisciplinary education with PHYWE

Geo science is one of the most multidisciplinary subjects taught in natural sciences. The first semesters or introductory courses cover general topics in physics, chemistry and biology followed by classical topics of geo science such as: geology, petrology, palaeontology, mineralogy, environment (climate, soil, water), spectroscopy, or X-ray analyses. Find corresponding experiments in this catalogue or refer to our TESS expert and Demo expert catalogues Physics, Chemistry or Biology.

Geo Science

Bachelor of Science Course – Reference Curriculum

Content	1. Sem.	2. Sem.	3. Sem.	4. Sem.	5. Sem.	6. Sem.
Laboratory Experiments	General Chemistry**		Optics and Microscopy***	Water: Cycle and Quality (Chapter 8.1)	General Biology***	Ore Microscopy, Nanoimaging (Chapter 3)
	General Physics*		Geochemistry	Soil Science (Chapter 8.3)	Mineralogy and Crystallography (Chapter 4.1)	Elementary Analysis/ Spectroscopy (e.g. XRF) (Chapter 4.1, 8.4)
Lecture, Tutorial, Experiments		Introductory Geology	Mineralogy and Petrology	Geophysics	Geoecology (Chapter 8)	Petrology / Petro-chemistry**
Elective Subject		Metallurgy**	Atmosphere: Science, Climate, and Change (Chapter 8.2)	Meteorology	Water: Hydrogeology, Hydrochemistry**	X-ray Powder Diffraction Laboratory (Chapter 8.9)
Theoretical Courses	Mathematics		Palaeontology	Sedimentation	Digital Mapping	
	Geology	Mineralogy	Sedimentary / Igneous	Petrology	Geomorphology	Meteorology, Climatology
Field Studies	e.g. Field Mapping		e.g. Landscape Evolution and Analysis		e.g. Environmental Geology	
Bachelor Thesis						Bachelor Thesis

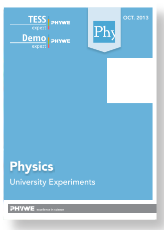
More than 60% of the experimental courses are covered by PHYWE experiments!

PHYWE Experiments available in this catalogue.

* Please refer to TESS expert Physics catalogue

** Please refer to TESS expert Chemistry catalogue

*** Please refer to TESS expert Biology catalogue



TESS expert and Demo expert Physics

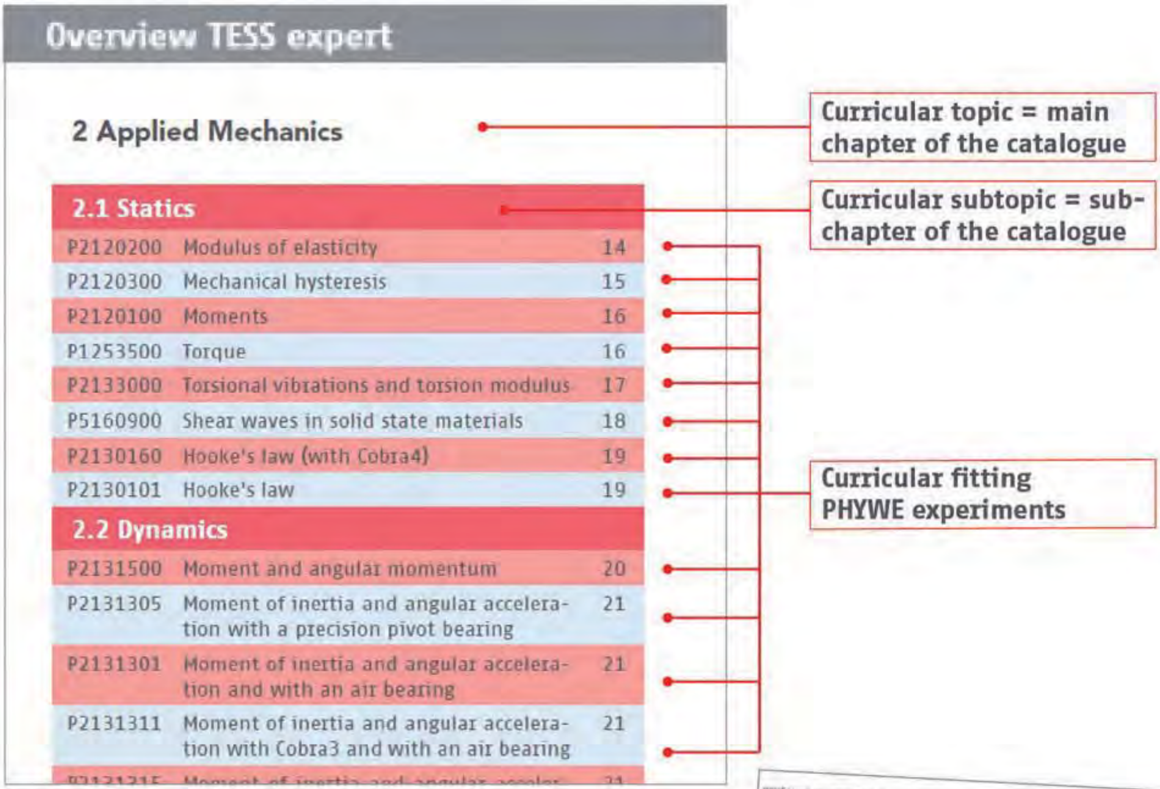
TESS expert and Demo expert Chemistry / Pharmacy

TESS expert and Demo expert Biology

TESS expert Engineering and Geo Science

How to use
the table of contents

Use the curricula-based content on the next pages to find your topics and our corresponding experiments. The TESS expert catalogue is adapted to international university curricula making it easy for you to find experiments corresponding to your desired topic. On each page you find the detailed description of one of our university level experiments. More information including the complete experiment description is available on our website **www.phywe.com.**



Find the overview of all experiments fitting to the international reference curriculum on our hompage!

Click www.phywe.com

2 Applied Mechanics

3 Materials Science

3.4 X-ray Structural Analysis

3.5 X-ray Fluorescence Analysis

3.6 Nanotechnology

3.7 Metallography

4 Non-destructive Testing (NDT)

4.1 X-ray Investigations

5.3 Properties of Electrical Circuits

6 Renewable Energy

6.1 Preparatory Courses

6.2 Basic Principles

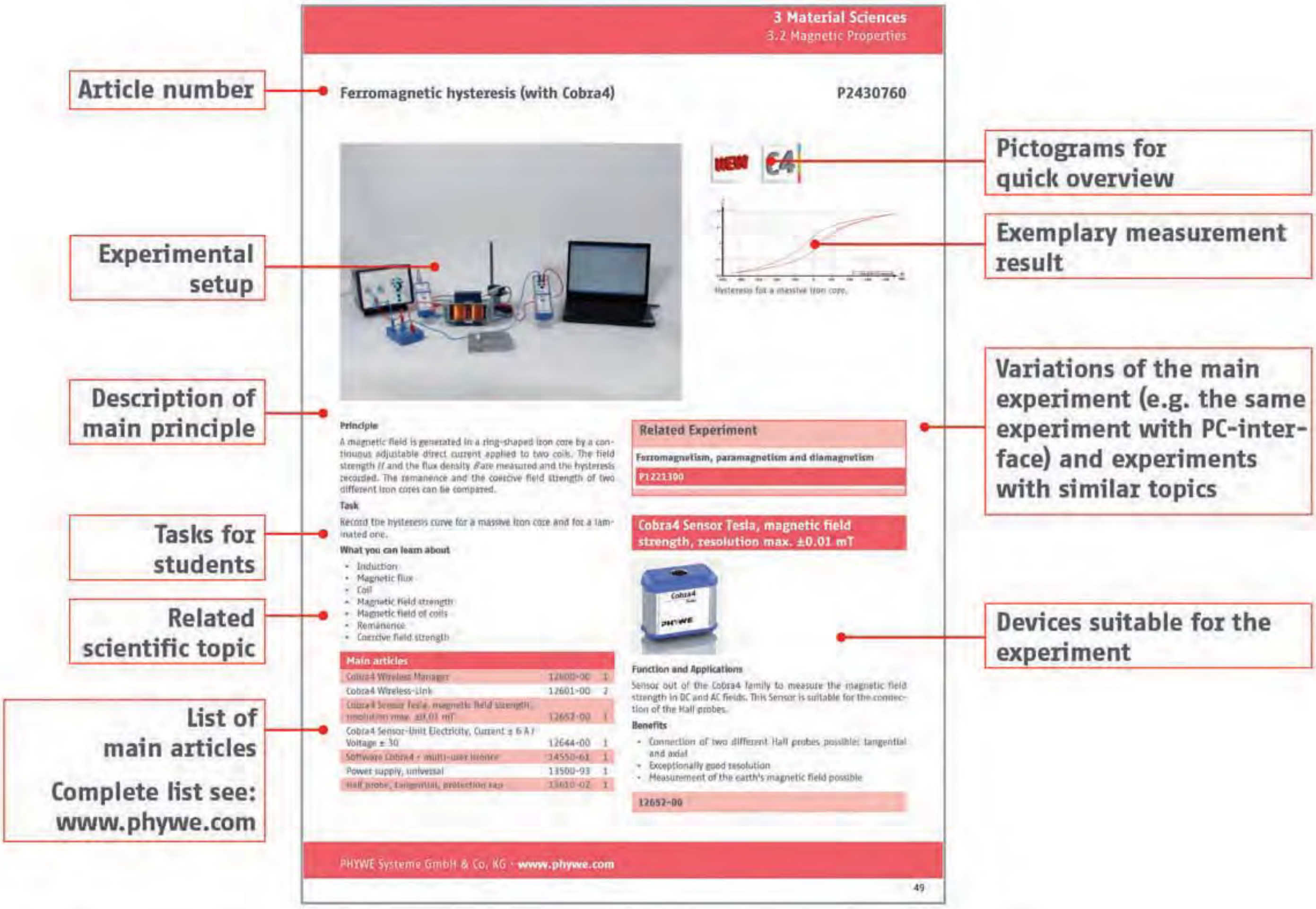
7 Photonics

8 Geo Science

How to use

Facts about the TESS expert catalogue

The TESS expert catalogue is adapted to the PHYWE reference curriculum. PHYWE's experiments fit to the content of experimental lectures and lab courses of schools, colleges and universities. The description of each experiment offers you a lot of information:



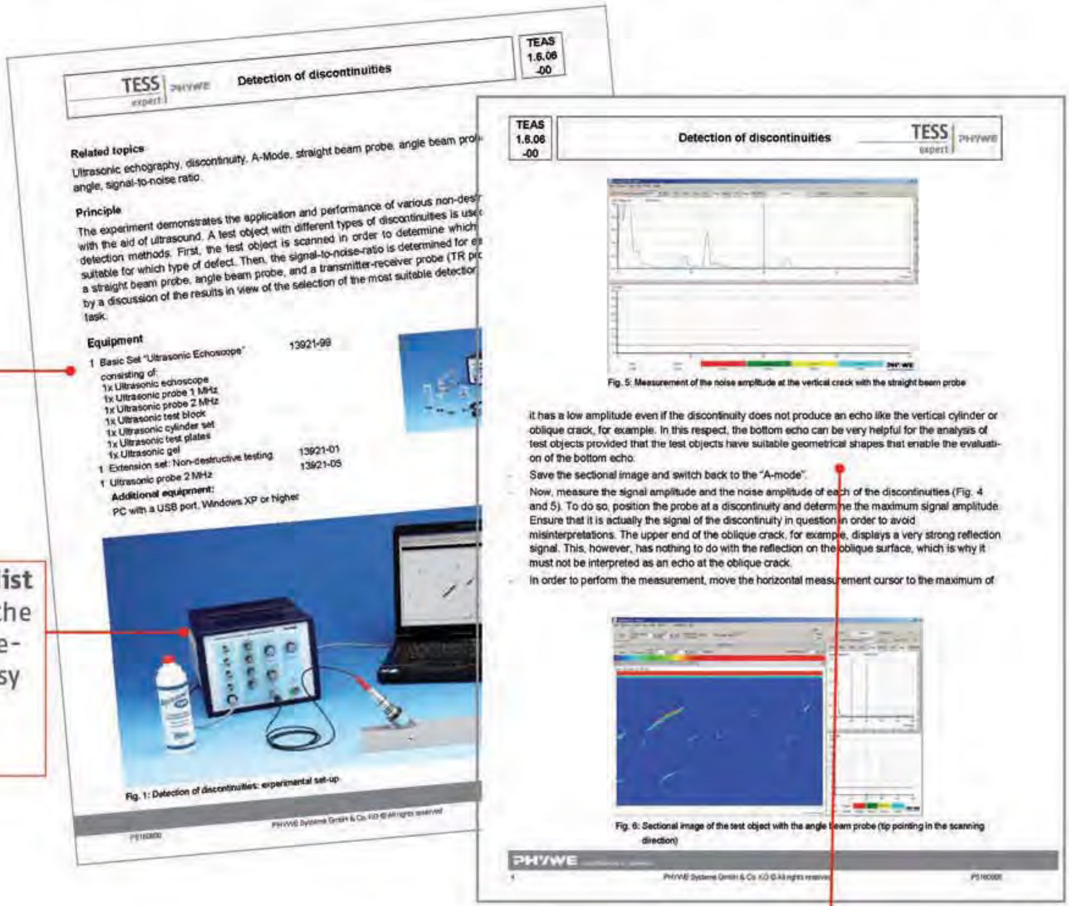
Pictograms for a quick overview of categories, related films or information:

- Experiments with the Computer based measuring system Cobra4
- Demonstration experiments
- Experiments with laser
- Experiments which have received a Nobel Prize
- Computer based measuring
- Experiments with radioactivity
- Product movie available - click at www.phywe.com
- New and completely revised experiments
- Training recommended

Didactic literature –
comprehensive guide for every experiment

Extensive experimental literature is available for all our university level experiments.
Rely on the advantages of our TESS expert experiment descriptions:

- All experiments are uniformly built up
- Experiments cover the entire range of classical and modern chemistry
- Didactically adapted descriptions – enables direct preparation by the student
- Developed and proven by practitioners – comfortable and reliable performance
- Excellent measurement accuracy – results agree with theory
- Computer-assisted experiments – easy, rapid assessment of results
- Modular experimental set-up – multiple use of individual devices, cost effective and flexible



Picture, Equipment list and Instruction for the execution of the experiment guarantee easy conduction of the experiment.

Theory and evaluation includes full theory of the experiment and shows graphical and numerical experimental results.

Your solution
with just one click!

WEB@ PHYWE

Our comprehensive Internet site **www.phywe.com** provides you with all the information you need covering the full spectrum of solutions and products from PHYWE – in five languages! Whether your specific needs involve physics, chemistry, biology or applied sciences, and whether you are looking for information relating to school or university-level materials, you can always find just the right products there quickly and easily.

Further highlights on our website include:

- More than 50 product videos
- Complete assembly instructions in video form
- Up-to-date software downloads
- Free-of-charge descriptions of the experiments
- Operating manuals and instruction sheets to download

1. Language
2. Subject area = Physics, Chemistry, Biology, Applied Sciences
3. Education level = School, University
4. Media e. g. product videos
5. Downloads e. g. experimental literature

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it better – find it.

Thomas Edison

The share of ideas and transfer of knowledge between academia and PHYWE is one of our major attempts in R&D. Our network is spread out worldwide and comprises cooperation projects, research assignments, and the education of expert staff.

Some breathtaking novelties of our new XR 4.0 plattform are one by one the result of fruitful cooperation in this regard - thank you!

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HILDESHEIM/HOLZMINDEN/GÖTTINGEN
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HAWK

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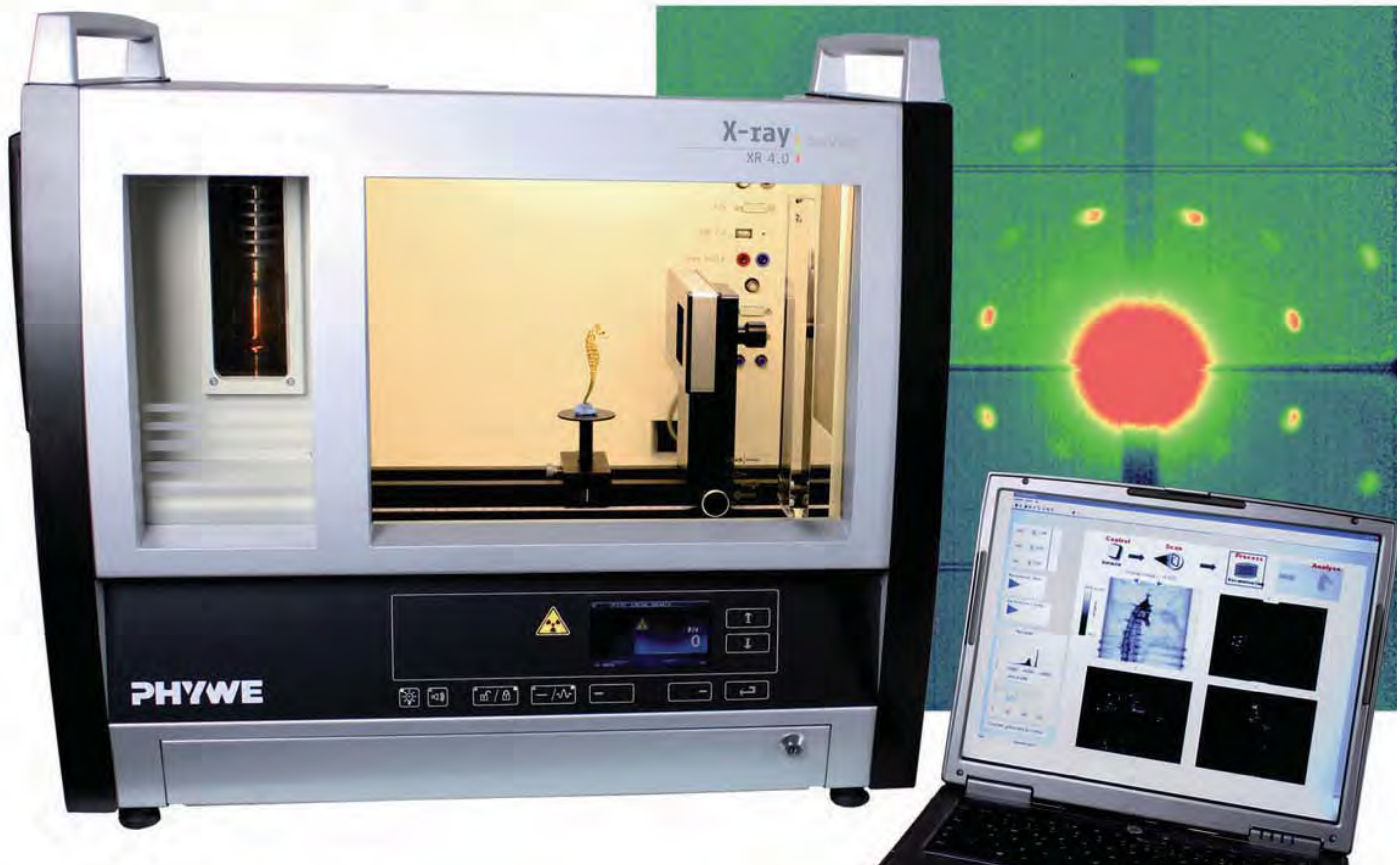
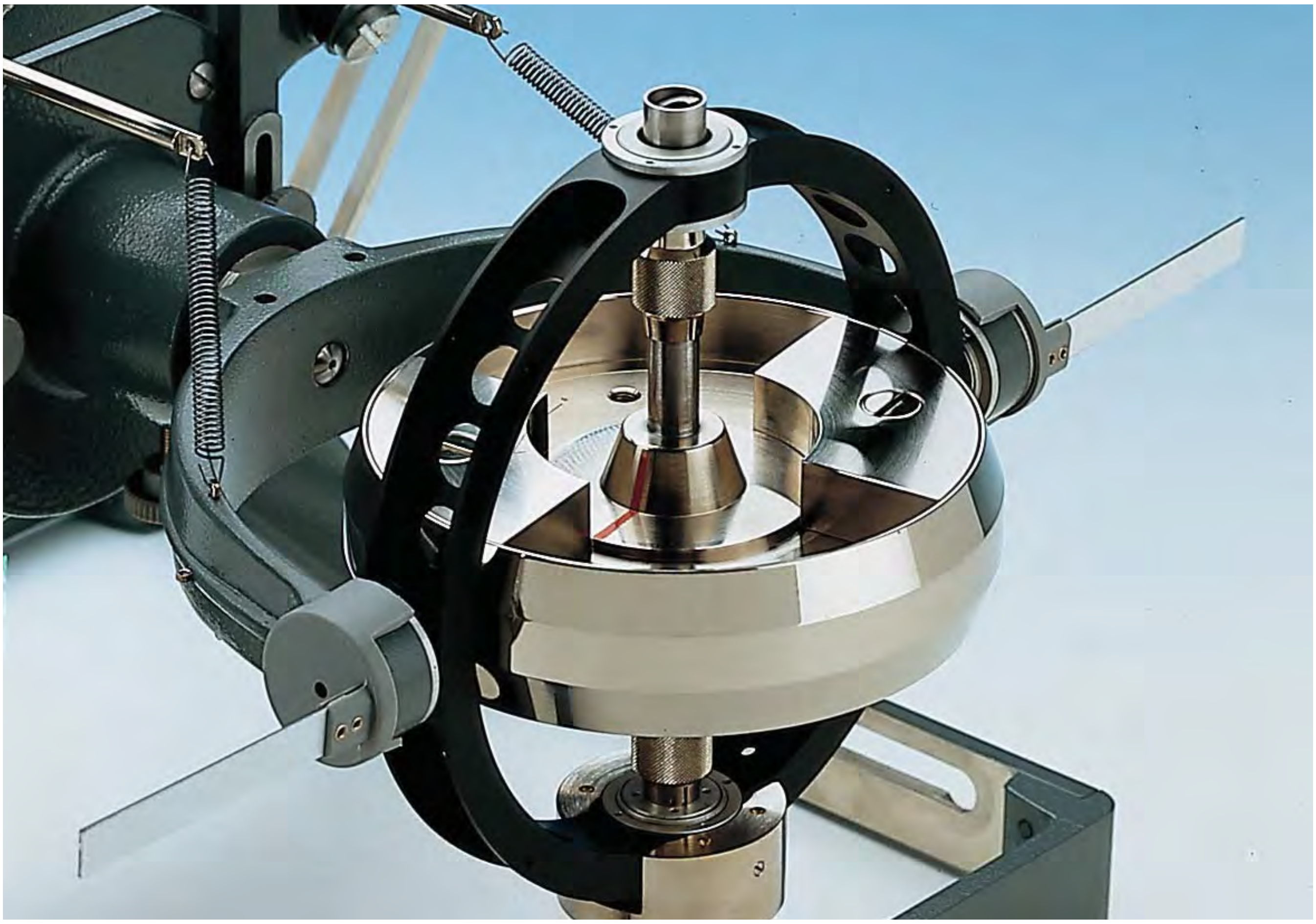
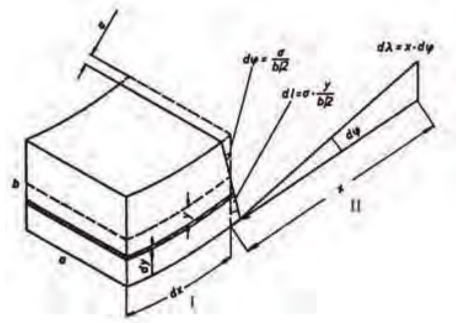
Göttinger Experimentallabor
für junge Leute e.V.





Applied Mechanics

P2120200 Modulus of elasticity



Deformation of a bar.

Principle

A flat bar is supported at two points. It is bent by the action of a force acting at its centre. The modulus of elasticity is determined from the bending and the geometric data of the bar.

Tasks

1. Determination of the characteristic curve of the dial gauge.
2. Determination of the bending of flatbars as a function of the force; at constant force: of the thickness, of the width and of the distance between the support points.
3. Determination of the modulus of elasticity of steel, aluminium and brass.

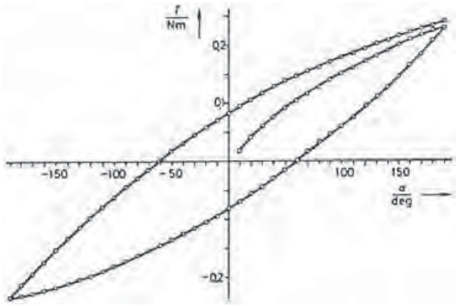
What you can learn about

- Young's modulus
- Modulus of elasticity
- Stress
- Deformation
- Poisson's ratio
- Hooke's law

Main articles		
Flat bars, set	17570-00	1
Dial gauge 10/0.01 mm	03013-00	1
Tripod base PHYWE	02002-55	2
Holder for dial gauge	03013-01	1
Knife-edge with stirrup	03015-00	1
Spring Balance 1 N	03060-01	1
Vernier caliper	03010-00	1

Mechanical hysteresis

P2120300



Mechanical hysteresis curve for the torsion of a copper rod of 2 mm diameter and 0.5 m long.

Principle

The relationship between torque and angle of rotation is determined when metal bars are twisted. The hysteresis curve is recorded.

Tasks

1. Record the hysteresis curve of steel and copper rods.
2. Record the stress-relaxation curve with various relaxation times of different materials.

What you can learn about

- Mechanical hysteresis
- Elasticity
- Plasticity
- Relaxation
- Torsion modulus
- Plastic flow
- Torque
- Hooke's law

Main articles		
Torsion apparatus	02421-00	1
Spring Balance 1 N	03060-01	1
Spring balance 2,5 N	03060-02	1
Torsion rod, Al, l = 500 mm, d = 4 mm	02421-06	1
Torsion rod, Al, l = 500 mm, d = 3 mm	02421-05	1
Torsion rod, Cu, l = 500 mm, d = 2 mm	02421-08	1
Torsion rod, steel, l = 500 mm, d = 2 mm	02421-01	1

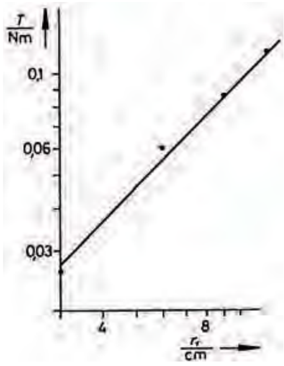
Torsion apparatus, complete

Function and Applications

To investigate deformations due to torques. For demonstration of the combined effects of force and lever.

02421-88

P2120100 Moments



Moment as a function of the distance between the origin of the coordinates and the point of action of the force.

Principle

Coplanar forces (weight, spring balance) act on the moments disc on either side of the pivot. In equilibrium, the moments are determined as a function of the magnitude and direction of the forces and of the reference point.

Tasks

1. Moment as a function of the distance between the origin of the coordinates and the point of action of the force.
2. Moment as a function of the angle between the force and the position vector to the point of action of the force.
3. Moment as a function of the force.

What you can learn about

- Moments
- Couple
- Equilibrium
- Statics
- Lever
- Coplanar forces

Main articles		
Moments disk	02270-00	1
Tripod base PHYWE	02002-55	2
Spring Balance 1 N	03060-01	2
Barrel base PHYWE	02006-55	1
Bolt with pin	02052-00	1
Fish line, l. 100m	02090-00	1
Support rod PHYWE,square,l 400mm	02026-55	2

Related Experiment

Torque

P1253500

Moments disk

Function and Applications

Disk to investigate general equilibrium conditions of a body submitted to forces and supported at its centre of gravity so that it can rotate.

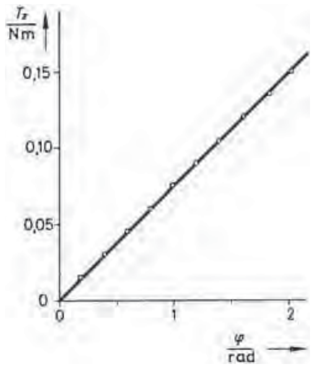
Equipment and technical data

- Metallic disk, white on both sides with a central hole for low friction support on rod with pin.
- One side with auxiliary circles with angular scales.
- Disk diameter: 270 mm.
- Number of holes: 64; Grid constant (mm): 30 x 30.

02270-00

Torsional vibrations and torsion modulus

P2133000



Torque and deflection of a torsion bar.

Principle

Bars of various materials will be exciting into torsional vibration. The relationship between the vibration period and the geometrical dimensions of the bars will be derived and the specific shear modulus for the material determined.

Tasks

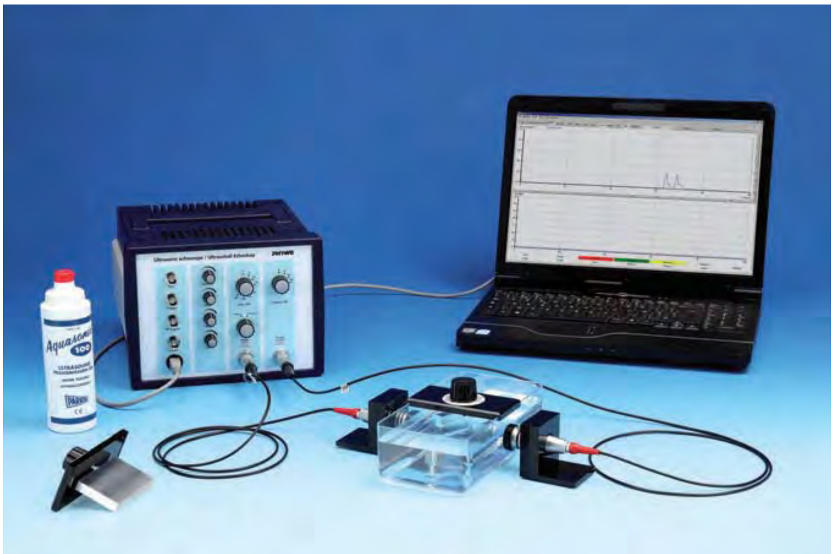
1. Static determination of the torsion modulus of a bar.
2. Determination of the moment of inertia of the rod and weights fixed to the bar, from the vibration period.
3. Determination of the dependence of the vibration period on the length and thickness of the bars.
4. Determination of the shear modulus of steel, copper, aluminium and brass.

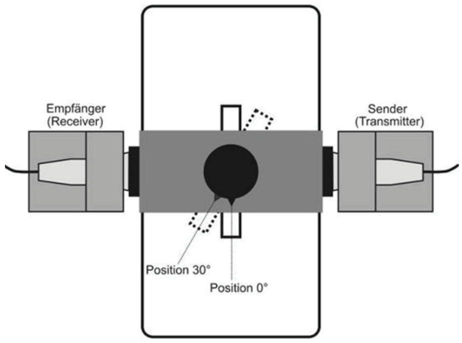
What you can learn about

- Shear modulus
- Angular velocity
- Torque
- Moment of inertia
- Angular restoring torque
- G-modulus
- Modulus of elasticity

Main articles		
Torsion apparatus	02421-00	1
Spring Balance 1 N	03060-01	1
Spring balance 2,5 N	03060-02	1
Torsion rod, Al, l = 500 mm, d = 4 mm	02421-06	1
Torsion rod, Al, l = 500 mm, d = 3 mm	02421-05	1
Sliding weight	03929-00	2

P5160900 Shear waves in solid state materials





Schematic set-up with an indication of the angular positions.

Principle

The aim of this experiment is to study the generation and propagation of ultrasound waves in solid objects. In addition, the additional generation of transverse wave modes (shear wave modes) resulting from an oblique angle of incidence should be identified and the sound velocities for the longitudinal and transverse component should be determined. The relationship between the coefficients of elasticity of the material and its sound velocities enables the determination of the magnitude of the coefficients.

Tasks

1. Determine the sound amplitude of an ultrasound wave passing through an acrylic glass plate (transmission measurement) as a function of the angle of incidence for the longitudinal and transverse component.
2. Use the measurement curves to determine the longitudinal sound velocity in acrylic glass based on the angle of the total reflection, and the transverse sound velocity based on the amplitude maximums and the angle of the total reflection.
3. Determine the sound amplitude of an ultrasound wave passing through an aluminium plate (transmission measurement) as a function of the angle of incidence for the longitudinal and transverse component.
4. Use the measurement curves to determine the longitudinal sound velocity in aluminium, based on the angle of the total reflection, and the transverse sound velocity based on the angle of the amplitude maximums and the angle of the total reflection.
5. Based on the transverse and longitudinal sound velocities, calculate the coefficient of elasticity for acrylic glass and aluminium.

What you can learn about

- Ultrasonic transmission measurement; propagation of ultrasound waves; ultrasound wave modes; shear waves; longitudinal and transverse waves; modulus of elasticity;sound velocity

Main articles		
Basic Set Ultrasonic echoscope	13921-99	1
Extension set: Shear waves	13921-03	1

Basic Set Ultrasonic echoscope

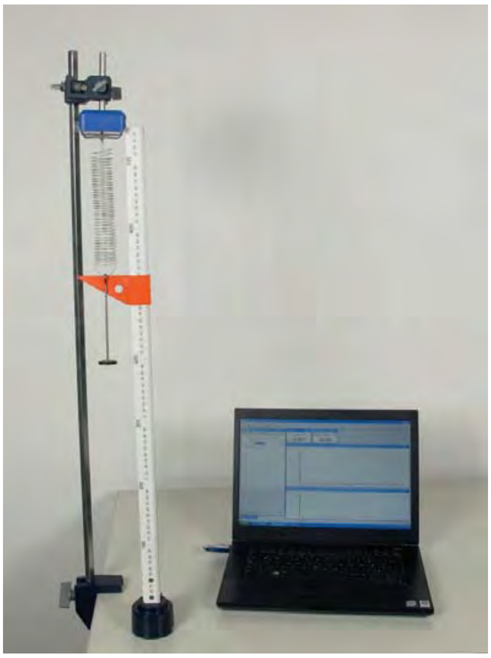
Function and Applications

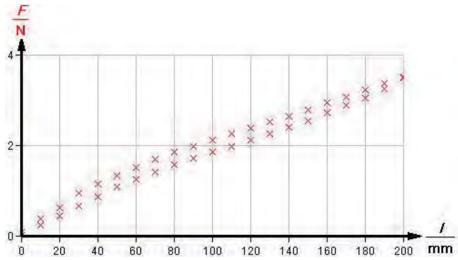
With the ultrasonic echoscope the basics of ultrasound and its wave characteristics can be demonstrated. Terms like amplitude, frequency, sound velocity or Time Gain Control TGC will be explained. The cylinder set can be used to vividly demonstrate reflection as well as sound velocity and frequency depending on attenuation in solid state materials. The knowledge e.g. regarding sound velocity will be used to measure the test block.
The principles of image formation from A-scan to B-scan can be explained. With the different probes the frequency depending resolution can be evaluated.

13921-99

Hooke's law (with Cobra4)

P2130160





Measurement of the elongation of a rubber band.

Principle

The validity of Hooke's Law is proven using various helical springs with different spring constants. In comparison, the behaviour of a stretched rubber band is examined, for which there is no proportionality between acting force and resulting extension.

Tasks

1. Measurement of the tensile force as a function of the path for three different helical springs and a rubber band.
2. Determination of the spring constant and evaluation of a hysteresis curve.
3. Verification of Hooke's law.

What you can learn about

- Spring constant
- Limit of elasticity
- Extension and compression

Main articles		
Cobra4 Wireless Manager	12600-00	1
Cobra4 Wireless-Link	12601-00	1
Cobra4 Sensor-Unit Force ± 4 N	12642-00	1
Software Cobra4 - multi-user licence	14550-61	1
Support base DEMO	02007-55	1
Scale, l = 750 mm, on rod	02200-00	1
Support rod PHYWE, square, l = 1000 mm	02028-55	1

Related Experiment

Hooke's law

P2130101

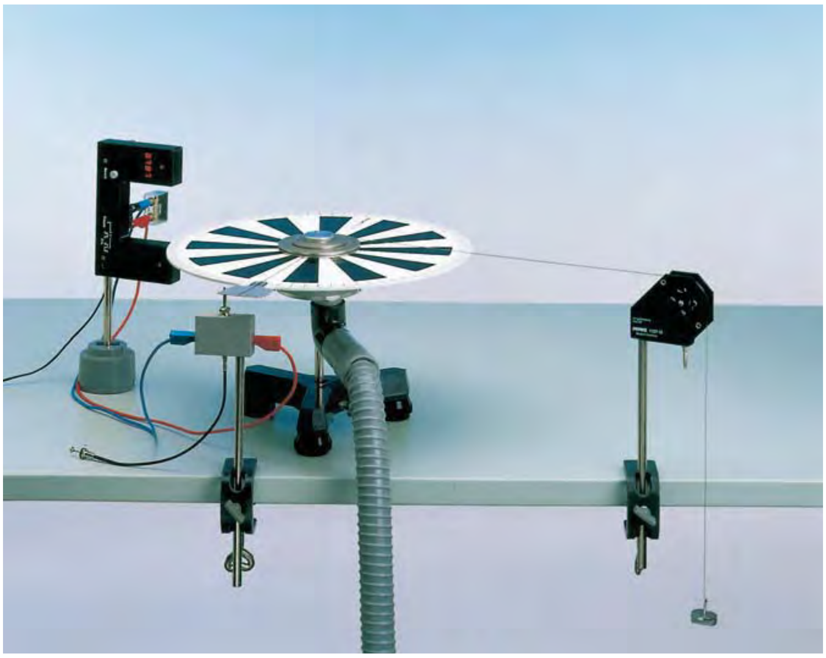
Cobra4 Sensor-Unit Force ± 4 N

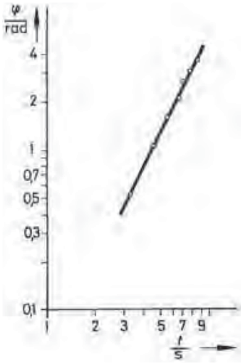
Function and Applications

The Cobra4 Sensor-Unit Force ± 4 N contains a bending beam (DMS technology), which converts the mechanical load into an electrical signal.

12642-00

P2131500 Moment and angular momentum





Angle of rotation as a function of time with uniformly accelerated rotary motion for m = 0.01 kg, r = 0.015 m.

Principle

The angle of rotation and angular velocity are measured as a function of time on a body which is pivoted so as to rotate without friction and which is acted on by a moment. The angular acceleration is determined as a function of the moment.

Tasks

With uniformly accelerated rotary motion, the following will be determined:

1. the angle of rotation as a function of time.
2. the angular velocity as a function of time.
3. the angular acceleration as a function of time.
4. the angular acceleration as a function of the lever arm.

What you can learn about

- Circular motion
- Angular velocity
- Angular acceleration
- Moment of inertia
- Newton's laws
- Rotation

Main articles		
Blower 230V/50Hz	13770-97	1
Air bearing	02417-01	1
Light barrier with counter	11207-30	1
Holding device w. cable release	02417-04	1
Turntable with angle scale	02417-02	1
Precision pulley	11201-02	1
Tripod base PHYWE	02002-55	1

Turntable with angle scale

Function and Applications

Aluminium disk for rotator with air bearing (02417.88).

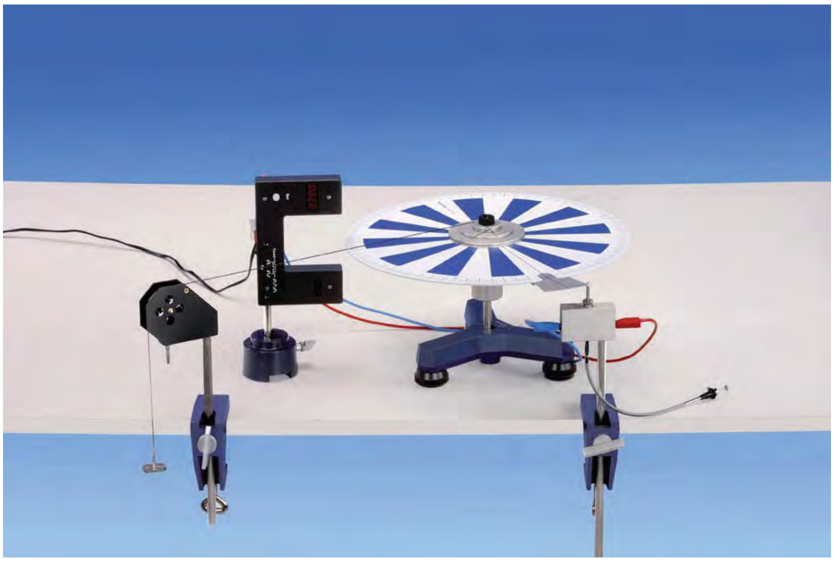
Equipment and technical data

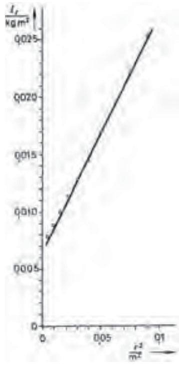
- Painted white, with hole for axis bolt.
- Demonstrative 15° subdivision and fine scale with 1° subdivision.
- Moment of inertia: 126 kg cm².
- Diameter: 350 mm.
- Fine/rough angle scale: 1°/15°.

02417-02

Moment of inertia and angular acceleration with a precision pivot bearing

P2131305





Moment of inertia of a mass point as a function of the square of its distance from the axis of rotation.

Principle

A moment acts on a body which can be rotated about a bearing without friction. The moment of inertia is determined from the angular acceleration.

Tasks

From the angular acceleration, the moment of inertia is determined as a function of the mass and the distance from the axis of rotation

1. of a disc
2. of a bar
3. of a mass point

What you can learn about

- Angular velocity
- Rotary motion
- Moment
- Moment of inertia of a disc
- Moment of inertia of a bar
- Moment of inertia of a mass point

Main articles		
Precision pivot bearing	02419-00	1
Light barrier with counter	11207-30	1
Inertia rod	02417-03	1
Holding device w. cable release	02417-04	1
Turntable with angle scale	02417-02	2
Precision pulley	11201-02	1
Tripod base PHYWE	02002-55	1

Related Experiments

Moment of inertia and angular acceleration and with an air bearing

P2131301

Moment of inertia and angular acceleration and with an air bearing (with Cobra3)

P2131311

Moment of inertia and angular acceleration and a precision pivot bearing (with Cobra3)

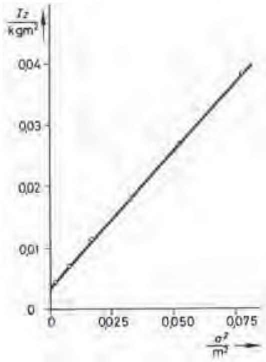
P2131315

Cobra4 Experiment – available 2013

Moment of inertia and angular acceleration (with Cobra4)

P2131360

P2133100 Moments of inertia and torsional vibrations



Moment of inertia of two equal masses, of 0.214 kg each, as a function of the distance between them.

Principle

Various bodies perform torsional vibrations about axes through their centres of gravity. The vibration period is measured and the moment of inertia determined from this.

Tasks

The following will be determined:

1. The angular restoring moment of the spiral spring.
2. The moment of inertia a) of a disc, two cylinder, a sphere and a bar, b) of two point masses, as a function of the perpendicular distance to the axis of rotation. The centre of gravity lies in the axis of rotation.

What you can learn about

- Rigid body
- Moment of inertia
- Axis of rotation
- Torsional vibration
- Spring constant
- Angular restoring moment
- Moment of inertia of a sphere, a disc, a cylinder, a long bar and of 2 point masses

Main articles		
Light barrier with counter	11207-30	1
Rotation axle	02415-01	1
Sphere	02415-02	1
Rod with movable masses	02415-06	1
Hollow cylinder	02415-04	1
Disk	02415-03	1
Solid cylinder	02415-05	1

Related Experiment

Moment of inertia / Steiner's theorem

P2132801

Rotation axle

Function and Applications

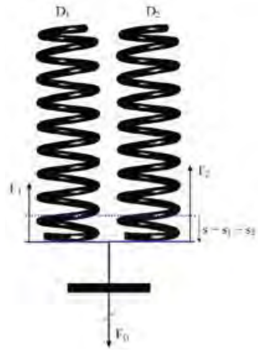
A rotabel axle supports at two places in a frame which is held by a spiral spring to the frame. The axle, which projects at the top, carries a flange with tightening screw to take the various model objects. A tensions rod is applied to the frame, the axis of which coincides with the rotating axle of the instrument.

Equipment and technical data

- Height: 180 mm; Diameter stem: 10 mm.
- Spring constant: 2.5 Ncm/rad.

02415-01

Harmonic oscillations of spiral springs – Spring linked in parallel and series (with Cobra4) P2132660



Parallel connection of helical springs.

Principle

The spring constant *D* is determined for different experimental set-ups from the oscillation period and the suspended mass.

Tasks

1. Determination of the spring constant *D* for different springs.
2. Determination of the spring constant for springs linked in parallel.
3. Determination of the spring constant for springs linked in series.

What you can learn about

- Spring constant
- Hooke's law oscillations
- Limit of elasticity
- Parallel springs
- Serial springs
- Use of an interface

Main articles		
Cobra4 Wireless Manager	12600-00	1
Cobra4 Wireless-Link	12601-00	1
Cobra4 Sensor-Unit Force ± 4 N	12642-00	1
Software Cobra4 - multi-user licence	14550-61	1
Tripod base PHYWE	02002-55	1
Support rod PHYWE, square, l = 1000 mm	02028-55	1
Right angle clamp PHYWE	02040-55	1

Cobra4 Sensor-Unit Force ± 4 N

Function and Applications

The Cobra4 Sensor-Unit Force ± 4 N contains a bending beam (DMS technology), which converts the mechanical load into an electrical signal.

Benefits

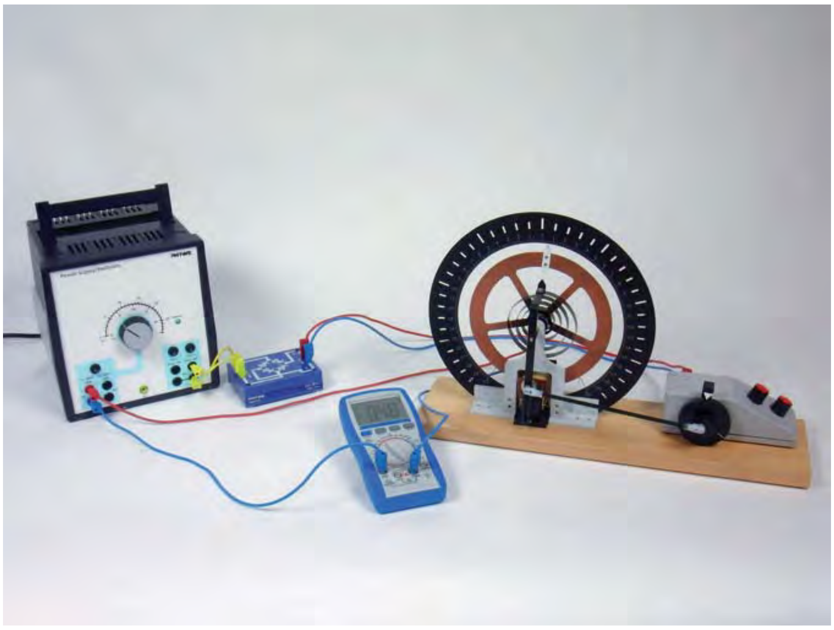
- Depending on the type of application, the force sensor can be connected to the Cobra4 Wireless-Link, the Cobra4 Mobile-Link, the Cobra4 Junior-Link or the Cobra4 USB-Link using a secure and reliable plug-in / lockable connection.
- On the top of the casing, a plate can be plugged in for measuring weights that are placed on it.
- On the bottom of the device, there is a hook on which weights may be hung.
- On the mechanically secure in take of the Cobra4 sensor unit, force from above or below is applied using a drop rod with a M6 thread.

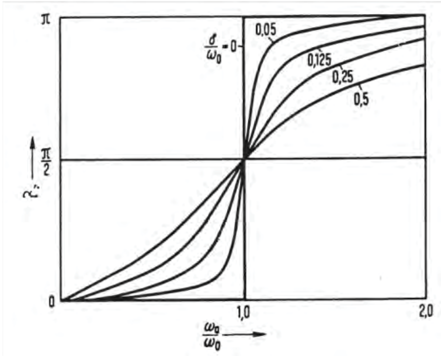
Equipment and technical data

- 100 mm long rod with M6 thread
- Weight plate, weight hook
- Operating manual
- Measuring range: -4...+4 N
- Maximum sampling rate: 16 Hz
- Measuring accuracy: 0.2 mN
- Dimensions (L x B x H): 64 x 70 x 35 mm
- Weight: 100 g

12642-00

P2132701 Forced oscillations - Pohl's pendulum





Resonance curves for different dampings.

Principle

If an oscillating system is allowed to swing freely it is observed that the decrease of successive maximum amplitudes is highly dependent on the damping. If the oscillating system is stimulated to swing by an external periodic torque, we observe that in the steady state the amplitude is a function of the frequency and the amplitude of the external periodic torque and of the damping. The characteristic frequencies of the free oscillation as well as the resonance curves of the forced oscillation for different damping values are to be determined

Tasks

- **A. Free oscillation**

1. To determine the oscillating period and the characteristic frequency of the undamped case.
2. To determine the oscillating periods and the corresponding characteristic frequencies for different damping values. Successive, unidirectional maximum amplitudes are to be plotted as a function of time. The corresponding ratios of attenuation, the damping constants and the logarithmic decrements are to be calculated.
3. To realise the aperiodic case and the creeping.

- **B. Forced oscillation**

1. The resonance curves are to be determined and to be represented graphically using the damping values of *A*.
2. The resonance frequencies are to be determined and are to be compared with the resonance frequency values found before hand.
3. The phase shifting between the torsion pendulum and the stimulating external torque is to be observed for a small damping value assuming that in one case the stimulating frequency is far below the resonance frequency and in the other case it is far above it.

What you can learn about

- Angular frequency; Characteristic frequency; Resonance frequency
- Torsion pendulum; Torsional vibration; Torque and restoring torque
- Damped/ undamped free oscillation; Forced oscillation
- Ratio of attenuation/ decrement; Damping constant
- Logarithmic decrement; Aperiodic case; Creeping

Main articles		
Torsion pendulum after Pohl	11214-00	1
Variable transformer, 25 VAC/ 20 VDC, 12 A	13531-93	1
Bridge rectifier, 30V AC/1A DC	06031-10	1
Digital multimeter 2010	07128-00	1
Stopwatch, digital, 1/100 s	03071-01	1

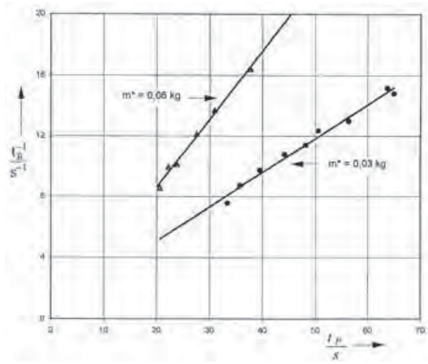
Cobra4 Experiment - available 2013

Forced oscillations - Pohl's pendulum (with Cobra4)

P2132760

Laws of gyroscopes / 3-axis gyroscope

P2131900



Determination of the momentum of inertia from the slope of straight line (tR)^-1 = f(tP).

Principle

The momentum of inertia of the gyroscope is investigated by measuring the angular acceleration caused by torques of different known values. In this experiment, two of the axes of the gyroscope are fixed. The relationship between the precession frequency and the gyro-frequency of the gyroscope with 3 free axes is examined for torques of different values applied to the axis of rotation. If the axis of rotation of the force free gyroscope is slightly displaced, a nutation is induced. The nutation frequency will be investigated as a function of gyro frequency.

Tasks

1. Determination of the momentum of inertia of the gyroscope by measurement of the angular acceleration.
2. Determination of the momentum of inertia by measurement of the gyro-frequency and precession frequency.
3. Investigation of the relationship between precession and gyro-frequency and its dependence from torque.
4. Investigation of the relationship between nutation frequency and gyro-frequency.

What you can learn about

- Momentum of inertia; Angular momentum
- Torque
- Precession; Nutation

Main articles		
Gyroscope with 3 axes	02555-00	1
Light barrier with counter	11207-30	1
Additional gyro-disk w. c-weight	02556-00	1
Power supply 5 V DC/2.4 A with 4 mm plugs	11076-99	1

Gyroscope with 3 axes

Function and Applications

Demonstration and practical set for working up the gyroscope laws.

Benefits

The following relationships can be produced:

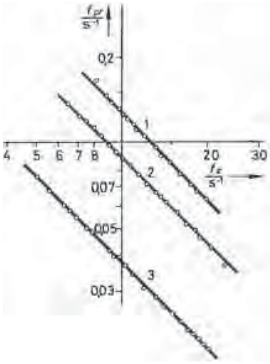
- Precession (influence of torque and rotational frequency)
- Nutation (influence of the speed of the disc on the nutational frequency)
- Measurement of the moment of inertia of the gyroscope disc from the angular acceleration for a known torque
- Investigation of the relationship between the duration of a precession rotation and the rotational frequency of the gyroscope disc; Investigation of the relationship between the precession frequency and the turning moment exerted on the gyroscope axis for constant rotational frequency of the disc
- Determination of the relationship between the rotational and nutational frequency of the gyroscope disc
- Gyroscope disc with double ball bearings, balanced and freely movable via 3 axes, which is wound up by hand with the aid of a thread
- Mounted on a metal stand; Sliding counterweight for calibrating the gyro disc

Equipment and technical data

- Disc diameter: 245 mm, Disc thickness: 25 mm
- Disc weight: approx. 1317 g, Counterweight: approx. 925 g

02555-00

P2132000 Laws of gyroscopes / cardanic gyroscope



Precession frequency as a function of the gyro frequency for different additional masses.

Principle

If the axis of rotation of the force-free gyroscope is displaced slightly, a nutation is produced. The relationship between precession frequency or nutation frequency and gyro-frequency is examined for different moments of inertia. Additional weights are applied to a gyroscope mounted on gimbals, so causing a precession.

Tasks

1. To determine the precession frequency as a function of the torque and the angular velocity of the gyroscope.
2. To determine the nutational frequency as a function of the angular velocity and the moment of inertia.

What you can learn about

- Moment of inertia
- Torque
- Angular momentum
- Nutation
- Precession

Main articles		
Gyroscope, Magnus type, incl. handbook	02550-00	1
Digital stroboscope	21809-93	1
Stopwatch, digital, 1/100 s	03071-01	1

Gyroscope, Magnus type, incl. handbook

Function and Applications

Gyroscope, Magnus type, universal gyroscope for demonstration and quantitative evaluation of gyroscope laws and their application.

Benefits

Rich accessories to demonstrate the following topics:

- Symmetrical and asymmetrical elonged and flattened gyroscope
- Force free, driven and captive gyroscope; navigational gyro compass

Equipment and technical data

- Steel gyroscope disc with reinforced edge suspended in gimbols with bolt bearings; Springs and clamps for restriction
- Variation of moments of inertia by supplementary steel-weights; Disk diameter: 128 mm; Storage box (mm): 355 x 380 x 385; Including manual of 124 pages

02550-00

Software "Measure Dynamics", campus licence

Function and Application

Software "measure Dynamics", automatic video analysis of movements. The new measurement software "measure Dynamics" provides an inexpensive way to analyze movements and display them in the shape of diagrams. All you need is a digital video camera, whereby modern webcams, camcorders or common digital cameras with film mode function are completely sufficient. The campus licence permits the installation of the software on every computer at the campus and on all personal PCs of the students and teachers belonging to the campus!

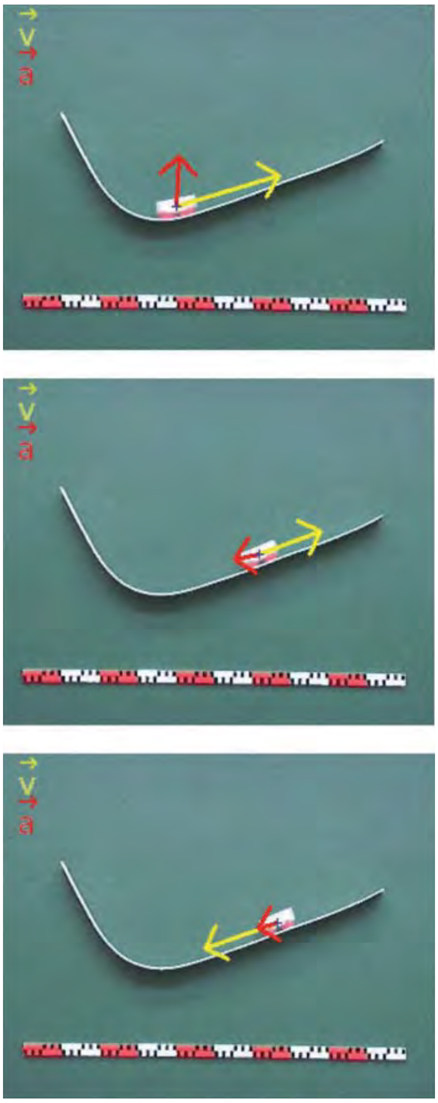
Benefits

- Automatic object recognition and tracing, including several filmed objects simultaneously, e.g. coupled pendulum.
- Dialogue-supported creation of trajectories as well as movement, velocity and acceleration diagrams.
- Stroboscopic effect for motion sequences (visualization of the entire path of movement).
- Easy data transfer of all measured values to MS Excel®, PHYWE measure, and other applications.
- Video processing inclusive of cutting, compression, etc.
- Software-guided modeling for didactical transfers (including homework).

Possible Applications

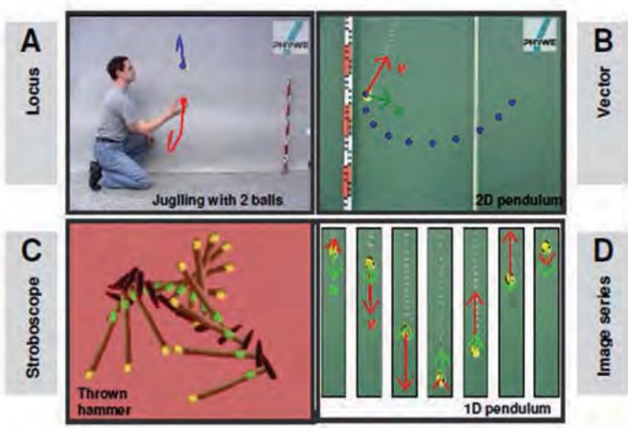
- Demonstration experiments in the lecture hall, for example, all types of one-dimensional and two-dimensional movements.
- "Field studies", for example, display of motion sequences in shot-putting, basket-shooting in basketball, trampoline jumping, high-jump, and much more.

14440-62



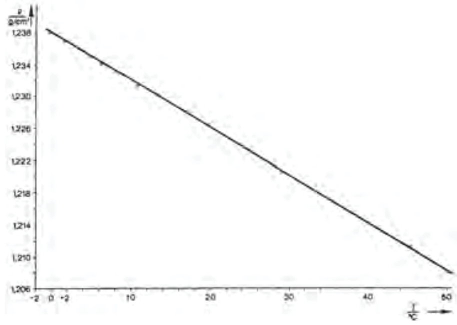
Speed and acceleration of a car in a roller coaster.

EduMedia Award for Didactical Software



Possibilities in measure Dynamics for supporting the phenomenological recording of movements.

P2140100 Density of liquids



Density of water as a function of temperature.

Principle

The density of water and glycerol is determined as a function of temperature using the Mohr balance.

Task

The density of water and glycerol is measured in 1 to 2 °C steps over a temperature range from 0 to 20 °C, then in larger steps up to 50 °C.

What you can learn about

- Hydrogen bond
- Water anomaly
- Volume expansion
- Melting
- Evaporation
- Mohr balance

Main articles		
Westphal/ Mohr density balance	45016-00	1
Immersion thermostat Alpha A, 230 V	08493-93	1
Bath for thermostat, makrolon	08487-02	1
External circulation set f. thermostat Alpha A	08493-02	1
Cooling coil for thermostat Alpha A	08493-01	1
Glycerol 250 ml	30084-25	2
Sodium chloride, 500 g	30155-50	1

Westphal / Mohr density balance

Function and Applications

Precision balance with balance bar with unequal arm length for determination of densities of liquids and solid state bodies.

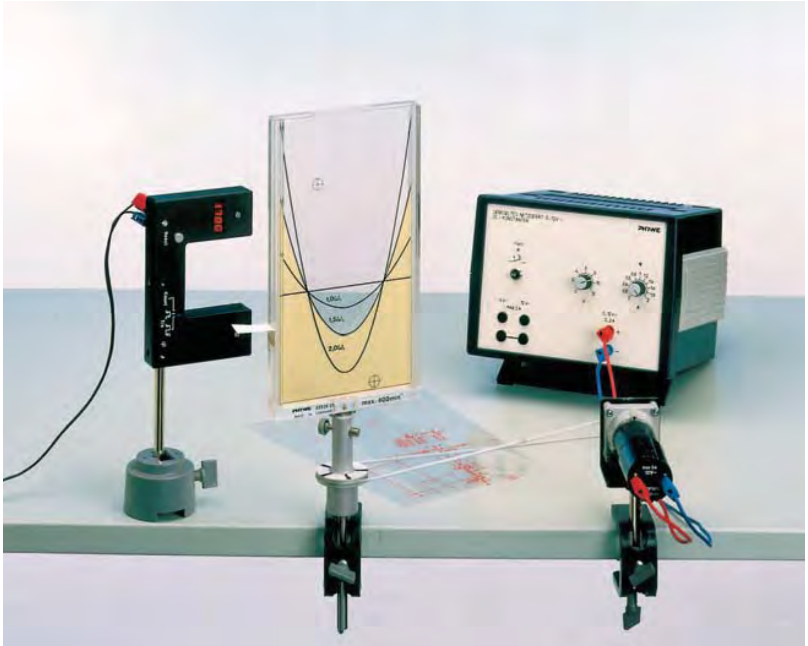
Equipment and technical data

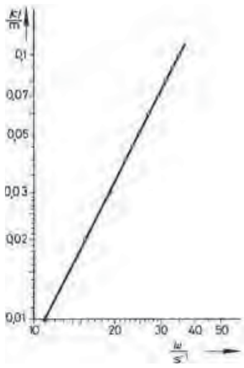
- The bearing of the balance bar consists of a low friction steel cutting edge, with height variable support rod
- Balance bar equipped with 9 positions for counter weight pieces
- Delivered in wooden storage box, counter weight pieces
- Tweezers, Reimann`s bouyancy body with wire, thermometer
- Glass cylinder, 100 ml, grid basket with hook for density determination of solid state bodies, beaker
- Weight range: 0...2 g/ccm; Sensitivity: 0.0001 g/ccm

45016-00

Surface of rotating liquids

P2140200





Location of the lowest point c of the liquid as a function of the angular velocity.

Principle

A vessel containing liquid is rotated about an axis. The liquid surface forms a paraboloid of rotation, the parameters of which will be determined as a function of the angular velocity.

Tasks

On the rotating liquid surface, the following will be determined:

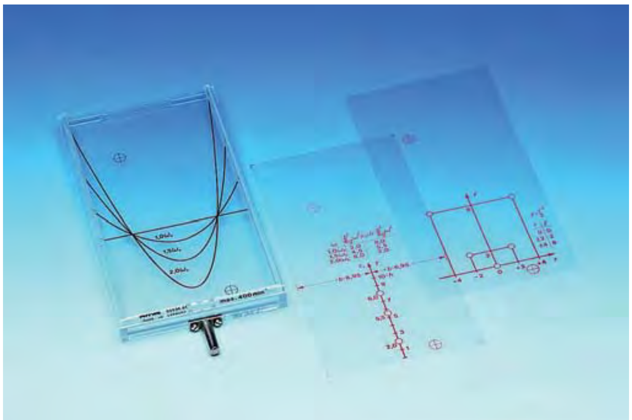
1. the shape,
2. the location of the lowest point as a function of the angular velocity,
3. the curvature.

What you can learn about

- Angular velocity
- Centrifugal force
- Rotary motion
- Paraboloid of rotation
- Equilibrium

Main articles		
Light barrier with counter	11207-30	1
Power supply 0...12 V DC/ 6 V, 12 V AC, 230 V	13505-93	1
Rotating liquid cell	02536-01	1
Motor, with gearing, 12 VDC	11610-00	1
Bearing unit	02845-00	1
Power supply 5 V DC/2.4 A with 4 mm plugs	11076-99	1
Bench clamp PHYWE	02010-00	2

Rotating liquid cell



Function and Applications

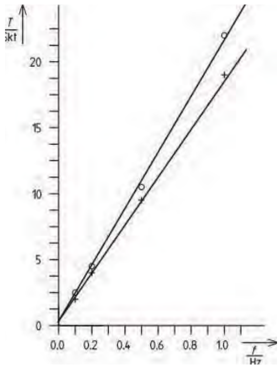
Rotatable cell on stem for investigation of surface shapes of liquids.

Equipment and technical data

- Flat Plexiglas cuvette with attachable transparent window with 3 different parabolas.
- 2 transparent slides with coordinates for quantitative investigation.
- Material: Plexiglas.
- Dimensions (mm): 138 x 5 x 265.
- Diameter stem: 10 mm.

02536-01

P2140300 Viscosity of Newtonian and non-Newtonian liquids (rotary viscometer)



Moment of rotation as a function of the frequency for a Newtonian liquid glycerol (+), liquid paraffin (o).

Principle

The viscosity of liquids can be determined with a rotation viscometer, in which a motor with variable rotation speed drives a cylinder immersed in the liquid to be investigated with a spiral spring. The viscosity of the liquid generates a moment of rotation at the cylinder which can be measured with the aid of the torsion of the spiral spring and read on a scale.

Tasks

1. Determine the gradient of the rotational velocity as a function of the torsional shearing stress for two Newtonian liquids (glycerine, liquid paraffin).
2. Investigate the temperature dependence of the viscosity of castor oil and glycerine.
3. Determine the flow curve for a non-Newtonian liquid (chocolate).

What you can learn about

- Shear stress
- Velocity gradient
- Internal friction
- Viscosity
- Plasticity

Main articles		
Rotary viscometer, 15 - 2,000,000 mPas, 110...240 V	18223-99	1
Magnetic stirrer MR Hei-Standard	35750-93	1
Electronic temperature controller EKT Hei-Con	35750-01	1
Glycerol 250 ml	30084-25	2
Castor oil 250 ml	31799-27	2

Rotary viscometer, 15 - 2,000,000 mPas, 110...240 V

Function and Applications

Classic rotational viscometer for the viscosity determination according to ISO2555 ("Brookfield method") and many ASTM standards.

Benefits

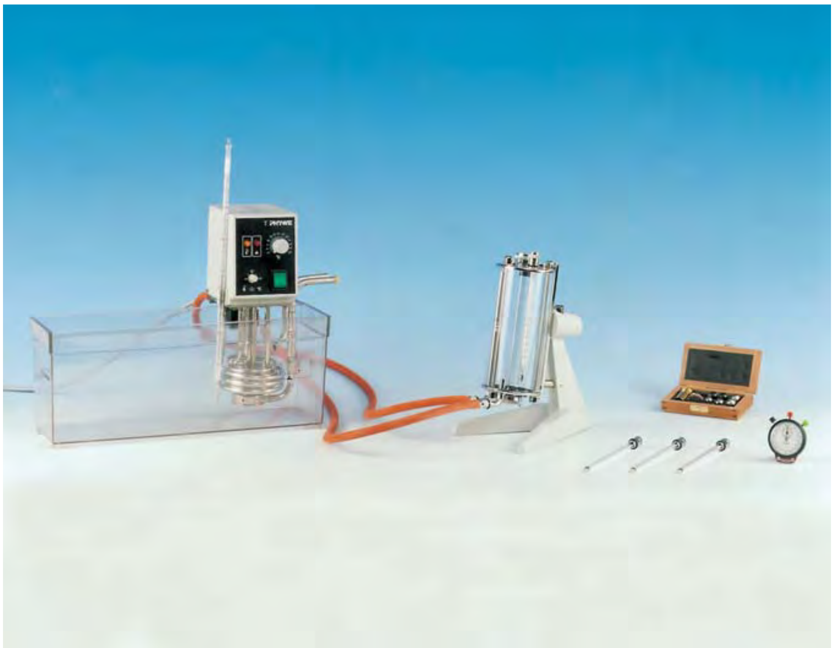
- The results are 100% compatible to the Brookfield method
- All results (viscosity, torque in %, speed, spindle) are displayed on the built-in display, multilanguage display: English, French, German, Spanish, Italian, Japanese, Portuguese, Dutch, Polish, Catalan
- Visual and acoustic signals at critical measuring conditions, Warning, if the device is used outside of the permissible measuring ranges, Digital speed control with "built-in"accuracy through stepping motor
- Touchless, optoelectronic torque measuring system with high accuracy and without wear

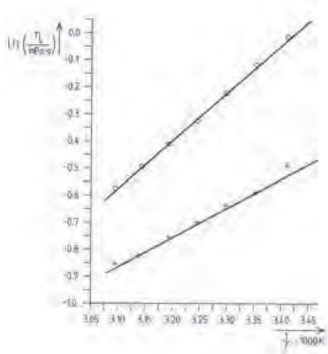
Equipment and technical data

- Viscosity range: 15 - 2,000,000 m Pas in 84 ranges (21 speeds and 4 spindles); Torque (rpm): 0.1/ 0.2/ 0.3/ 0.5/ 0.6/ 1/ 1.5/ 2/ 2.5/ 3/ 4/ 5/ 6/ 10/ 12/ 20/ 30/ 50/ 60/ 100/ 200

18223-99

Viscosity measurement with the falling ball viscometer **P2140400**





Temperature dependence of the dynamic viscosity of water (o) and methanol (+), respectively.

Principle

Due to internal friction among their particles, liquids and gases have different viscosities. The viscosity, a function of the substance's structure and its temperature, can be experimentally determined, for example, by measuring the rate of fall of a ball in a tube filled with the liquid to be investigated.

Tasks

Measure the viscosity

1. of methanol-water mixtures of various composition at a constant temperature,
2. of water as a function of temperature and
3. of methanol as a function of temperature.

From the temperature dependence of the viscosity, calculate the energy barriers for the displace ability of water and methanol.

What you can learn about

- Liquid; Newtonian liquid
- Stokes law; Fluidity
- Dynamic and kinematic viscosity
- Viscosity measurements

Main articles		
Falling ball viscometer	18220-00	1
Immersion thermostat Alpha A, 230 V	08493-93	1
Thermometer, 24...+ 51 °C, for 18220-00	18220-02	1
Bath for thermostat, makrolon	08487-02	1
External circulation set f. thermostat Alpha A	08493-02	1
Set of Precision Balance Sartorius CPA 623S and measure software, 230 V	49224-88	1

Falling ball viscometer

Function and Applications

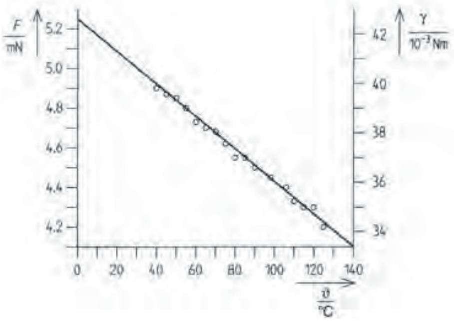
Falling ball viscometer.

Equipment and technical data

- Thermometer
- Diameter of the fall tube: 15.95 mm
- Initiable fall times: 25...300 s
- Fall distance: 100 mm
- 6 balls

18220-00

P2140500 Surface tension with the ring method (Du Nouy method)



Temperature dependency of surface tension of olive oil.

Principle

The force is measured on a ring shortly before a liquid film tears using a torsion meter. The surface tension is calculated from the diameter of the ring and the tear-off force.

Tasks

1. Determine the surface tension of olive oil as a function of temperature.
2. Determine the surface tension of water/methanol mixtures as functions of the mixture ratio.

What you can learn about

- Surface energy
- Interface
- Surface tension
- Adhesion
- Critical point
- Eötvös equation

Main articles		
Torsion dynamometer, 0.01 N	02416-00	1
Magnetic stirrer MR Hei-Standard	35750-93	1
Electronic temperature controller EKT Hei-Con	35750-01	1
Retort stand, 210 mm × 130 mm, h = 500 mm	37692-00	1
Ethyl alcohol, absolute 500 ml	30008-50	1
Surface tension measuring ring	17547-00	1
Water jet pump, plastic	02728-00	1

Torsion dynamometer, 0.01 N

Function and Applications

Torsion dynamometer to measure small forces or investigate electrostatic and magnetic interactions between bodies.

Benefits

- Force compensation; Zero point adjustment
- Eddy current damping element, Front and side scales
- Overload protection and a stem

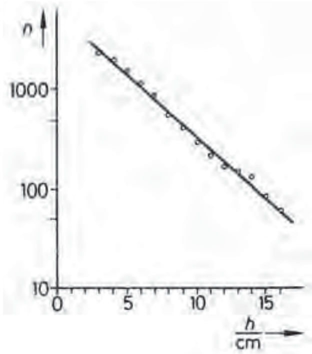
Equipment and technical data

- Range front scale: 10 mN; Range side scale: ±3 mN
- Raw subdivision: 1 mN; Fine subdivision: 0.1 mN
- Maximum lever load: 0.2 N
- Scale diameter: 170 mm; Length of lever arm: 240 mm

02416-00

Barometric height formula

P2140700



Number of steel balls (m = 0.034 g), as a function of the height h, which pass through the volume element V in 30 seconds (vibrational frequency 50 Hz).

Principle

Glass or steel balls are accelerated by means of a vibrating plate, and thereby attain different velocities (temperature model). The particle density of the balls is measured as a function of the height and the vibrational frequency of the plate.

Tasks

Measurement of the particle density as a function of:

1. the height, at fixed frequency.
2. the vibrational frequency of the exciting plate, at fixed height.

What you can learn about

- Kinetic gas theory
- Pressure
- Equation of state
- Temperature
- Gas constant

Main articles		
Kinetic gas theory apparatus	09060-00	1
Digital stroboscope	21809-93	1
Power supply variable 15 VAC/ 12 VDC/ 5 A	13530-93	1
Light barrier with counter	11207-30	1
Tripod base PHYWE	02002-55	2
Power supply 5 V DC/2.4 A with 4 mm plugs	11076-99	1
Stopwatch, digital, 1/100 s	03071-01	1

Kinetic gas theory apparatus

Function and Applications

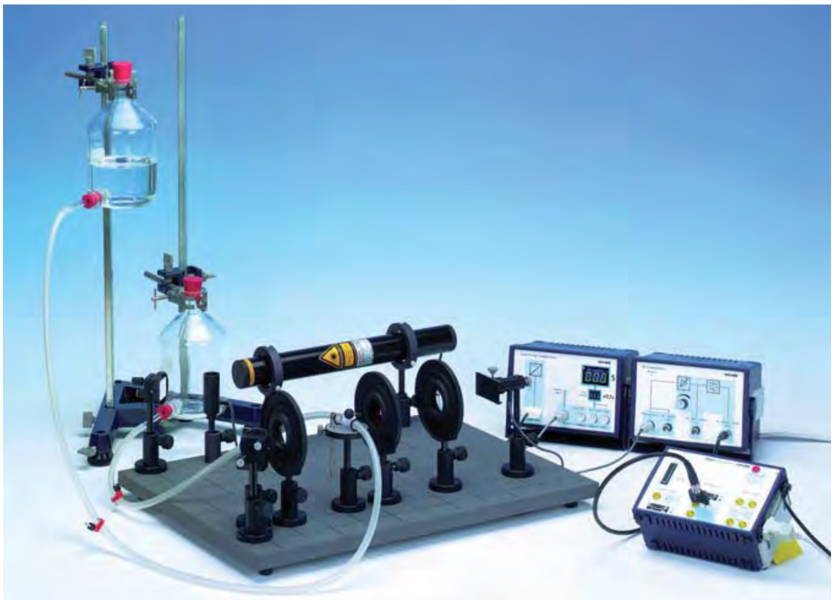
Kinetic gas theory apparatus with vertical chamber and built in motor.

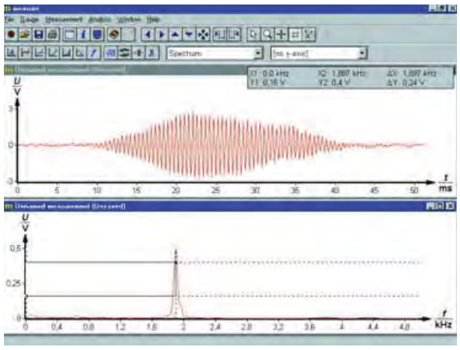
Equipment and technical data

- Chamber (mm) 60 x 20 x 180
- Motor supply 12 VDC /20 W

09060-00

P2260511 LDA - laser Doppler anemometry with optical base plate (with Cobra3)





Measurement of the signal spectrum with a signal peak.

Principle

Small particles in a current pass through the LDA measuring volume and scatter the light whose frequency is shifted by the Doppler effect due to the particle movement.

The frequency change of the scattered light is detected and converted into a particle or flow velocity.

Task

Measurement of the light-frequency change of individual light beams which are reflected by moving particles.

What you can learn about

- Interference
- Doppler effect
- Scattering of light by small particles (Mie scattering)
- High- and low-pass filters
- Sampling theorem
- Spectral power density
- Turbulence

Main articles		
He/Ne Laser, 5mW with holder	08701-00	1
Power supply for laser head 5 mW	08702-93	1
Cobra3 BASIC-UNIT, USB	12150-50	1
Si-Photodetector with Amplifier	08735-00	1
Optical base plate with rubberfeet	08700-00	1
Sliding device, horizontal	08713-00	1
LDA-Accessory-Set	08740-00	1

Cobra4 Experiment - available 2013

LDA - Laser Doppler Anemometry (with Cobra4)

P2260560

Control Unit for Si-Photodetector

Function and Applications

Amplifier for silicon photodetector.

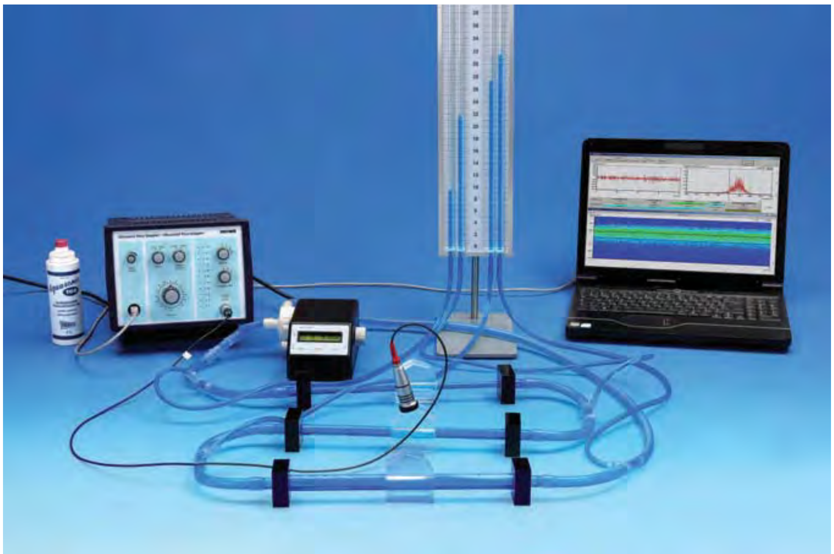
Equipment and technical data

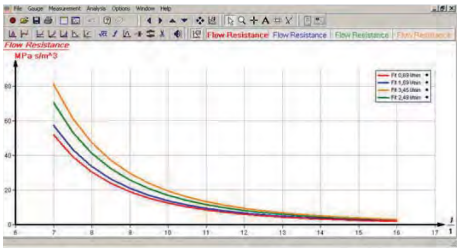
- 3 BNC outputs:
  Output 1 (monitor output), gain 1, bandwidth for DC ... 60 kHz
  Output 2, gain 1 ... 100, band width for AC 10 Hz ... 60 kHz
  Output 3 (filter output), gain 1 ... 100, band width for AC 200 Hz ...10 kHz
- Input: 5-pole diode socket for silicon photodetector
- Connections +9 V ... +12 V; Power consumption 1 W
- Impact-resistant plastic case (194 x 140 x 130) mm with carrying handle, includes 110-V/240-V power supply

08735-99

Mechanics of flow

P5140100





The dependence of the resistance on the tube diameter.

Principle

The Doppler effect is used with ultrasonic waves to investigate the laws of stationary laminar flow, which underlie a many great technical applications. The liquid under investigation flows through a circuit of tubing. Particular aspects to be studied experimentally include the relationship between the speed of flow and the surface of the tubing (continuity condition) plus that between the resistance to the flow and the diameter of the tube (Hagen-Poiseuille law). By means of these two laws, the dynamic viscosity or fluidity can be derived using familiar geometry.

Tasks

1. Measure the average speed of 3 different flows using the ultrasonic Doppler sonograph with Doppler prisms. Determine the nature of the flow.
2. Measure the drop in pressure between the measuring points and determine the resistance to the flow.
3. Calculate viscosity and fluidity and compare with those for other liquids.

What you can learn about

- Ultrasonic Doppler effect
- Laminar and turbulent flow
- Continuity equation
- Bernoulli's equation
- Hagen-Poiseuille law
- Viscosity and fluidity

Main articles		
Basic set: Ultrasonic Doppler technique	13923-99	1
Extension Set: Mechanics of flow	13923-01	1

Related Experiment

Flow Measurement Ultrasonic Doppler effect

P5142100

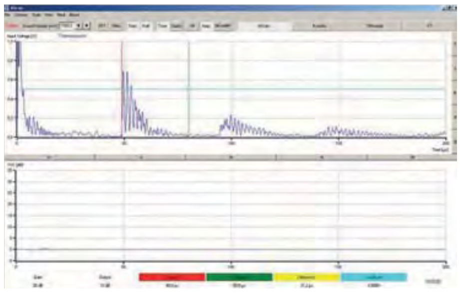
Basic set: Ultrasonic Doppler technique

Function and Applications

Kit containing instrument and accessories for general ultrasonic sonography experiments. The software displays the measured data from the ultrasonic Doppler apparatus, basic instrument of this kit, in realtime on the computer screen. Modular and extendable with accessory kits for experimentations in the fields of hydraulics and medical diagnostics.

13923-99

P5141100 Level measurement



Set-up of the ultrasonic probe for monitoring limit values and for continuous measurements.

Principle

For the experiment, a level measuring system for a two-phase liquid tank is set up and a calibration curve for the filling volumes is recorded. One task is to determine the minimum measurement volume ("dead band"). For maximum tank filling, an ultrasonic limit switch is to be tested. Level measurements play an important role for many industrial processes. Particularly for the automation of these processes, level meters are used to determine the content volume of tank systems, silos, reactors, collecting reservoirs, etc.

Tasks

1. Set up a level measurement system for continuous measurements.
2. Determine the minimum detectable filling level ("dead band") and the associated liquid volume.
3. Perform a volume calibration for two different liquids (water and oil) for the tank.
4. Record and analyse suitable ultrasound signals for a limit switch.
5. Perform a level measurement with a two-phase system (water-oil).

What you can learn about

- Limit value monitoring; Continuous measurement
- Initial echo; Multiple reflections
- Time of flight; Sound velocity; Acoustic impedance

Main articles		
Basic Set Ultrasonic echoscope	13921-99	1
Support base variable	02001-00	1
Universal clamp	37718-00	2
Boss head	02043-00	2
Graduated cylinder 250 ml	36630-00	1

Basic Set Ultrasonic echoscope

Function and Applications

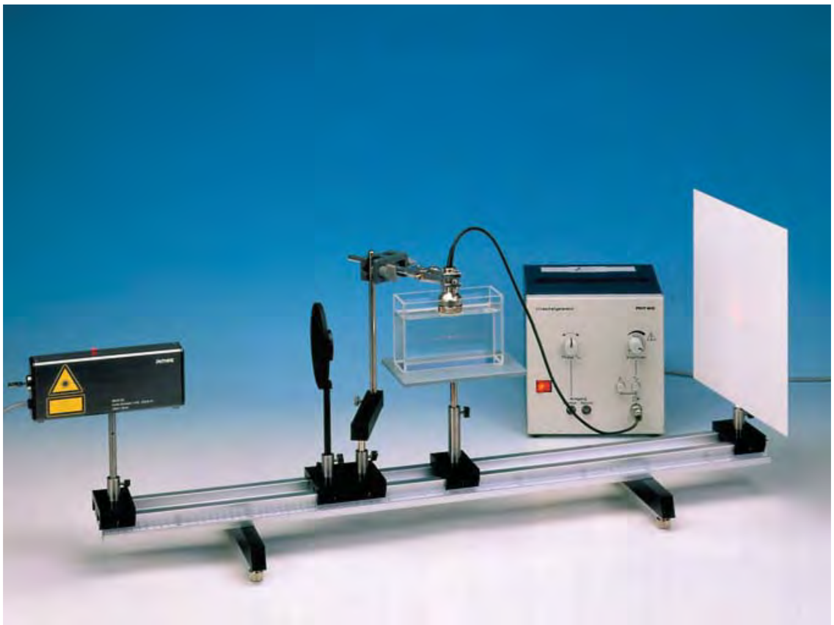
With the ultrasonic echoscope the basics of ultrasound and its wave characteristics can be demonstrated. Terms like amplitude, frequency, sound velocity or Time Gain Control TGC will be explained.

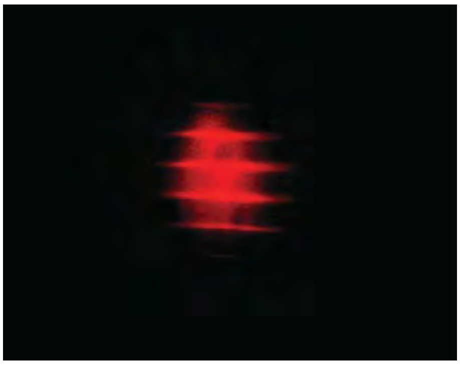
The cylinder set can be used to vividly demonstrate reflection as well as sound velocity and frequency depending on attenuation in solid state materials.

The knowledge e.g. regarding sound velocity will be used to measure the test block. The principles of image formation from A-scan to B-scan can be explained. With the different probes the frequency depending resolution can be evaluated.

13921-99

Optical determination of the velocity of sound in liquids — P2151000





Resulting diffraction pattern on the screen.

Principle

A stationary ultrasonic wave in a glass cell full of liquid is traversed by a divergent beam of light. The sound wave length can be determined from the central projection of the sound field on the basis of the refractive index which changes with the sound pressure.

Tasks

To determine the wavelength of sound in liquids, and from this calculate the sound velocity, from the structure of the centrally projected image.

What you can learn about

- Ultrasonics
- Sound velocity
- Frequency
- Wavelength
- Sound pressure
- Stationary waves

Main articles		
Ultrasonic generator	13920-99	1
Laser, He-Ne, 1.0 mW, 230 V AC	08181-93	1
Glass cell, 150x55x100 mm	03504-00	1
Optical profile-bench, l 1000mm	08282-00	1
Screen, metal, 300 x 300 mm	08062-00	1
Swinging arm	08256-00	1
Slide mount for optical bench, h = 80 mm	08286-02	1

Ultrasonic generator

Function and Applications

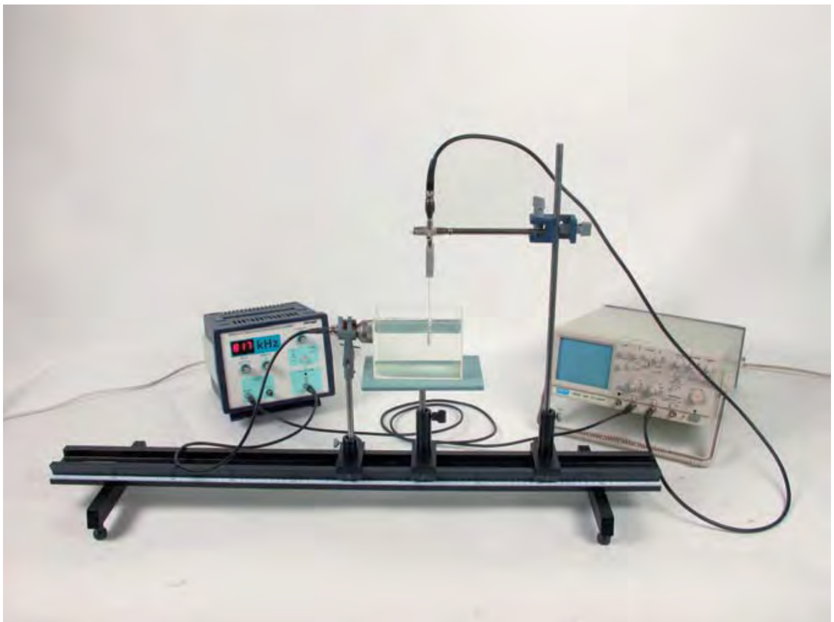
Ultrasonic generator for sine- and pulse operation for experimentation with wave phenomena and run time measurements, for exemplatory technical applications e.g. ultrasonic welding.

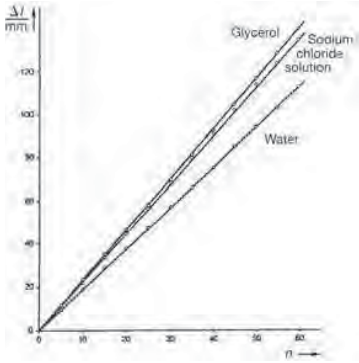
Equipment and technical data

- With 3-digit LED for frequency and adjustable frequency for optimisation experiments and exactly determination of wave length under different experimental conditions.
- Monitor- and trigger-outputs with BNC sockets for phase determination with an oscilloscope.
- Robust plastic housing; Including sealed sound head
- Frequency range (sinus): 780...820 kHz
- Maximum sound output power: 16 W
- Puls repetition frequency: 500 Hz
- Puls duration: 3 µs; Supply voltage: 110...240 V AC
- Dimensions, H × W × D (mm): 170 × 232 × 260; Mass: 3.67 kg

13920-99

P2151100 Phase and group velocity of ultrasound in liquids





Detector displacement l as a function of the number n of wavelengths covered, for water, glycerol and sodium chloride solution (temperature = 25 °C).

Principle

The sound waves transmitted to a liquid by the ultrasonic generator are picked up by a piezoelectric ultrasonic pick-up and the signal from transmitter and receiver compared on an oscilloscope.

The wavelength is determined and the phase velocity calculated from the relative phase position of the signals.

The group velocity is determined from measurements of the sound pulse delay time.

Tasks

The signals from the ultrasonic generator and the ultrasonic pick-up are recorded on the oscilloscope.

1. To measure the relative phase position of the signal from the ultrasonic pick-up as a function of its distance from the ultrasonic generator (which is in the sine mode), and to determine the ultrasonic wavelength and the phase velocity when the frequency is known.
2. To determine the oscilloscope's coefficient of sweep with the aid of the ultrasonic frequency.
3. With the generator in the pulsed mode, to record the delay time of the sound pulses as a function of the distance between a generator and the pick-up, and to determine the group velocity.

What you can learn about

- Longitudinal waves
- Velocity of sound in liquids
- Wavelength
- Frequency
- Piezoelectric effect
- Piezoelectric ultrasonics transformer

Main articles		
Ultrasonic generator	13920-99	1
30 MHz digital storage oscilloscope with colour display, 2 x BNC cables l =75 cm incl.	11462-99	1
Ultrasonic pickup	13920-00	1
Glass cell, 150x55x100 mm	03504-00	1
Optical profile bench l = 60 cm	08283-00	1
Slide mount for optical bench, h = 80 mm	08286-02	1
Distributor	06024-00	1

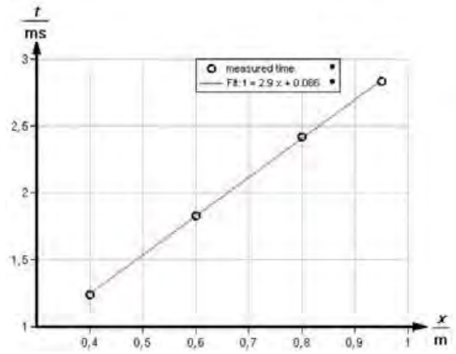
Related Experiment

Temperature dependence of the velocity of ultrasound in liquids

P2151200

Velocity of sound in air with Universal Counter

P2150305



Propagation time as function of distance: measurements and fitted function.

Principle

The velocity of sound in air is determined by measurement of sound travel times across known distances.

Task

Determine the sound velocity in air for different distances between sound source and microphone.

What you can learn about

- Wave propagation
- Longitudinal wave
- Air pressure variation
- Sound wave
- Impulse of sound

Main articles		
Universal Counter	13601-99	1
Measuring microphone w.amplifier	03543-00	1
Barrel base PHYWE	02006-55	2
Support	09906-00	1
Support rod with hole, stainless steel, 10 cm	02036-01	2
Measuring tape, l = 2 m	09936-00	1
Flat cell battery, 9 V	07496-10	1

Universal Counter

Function and Applications

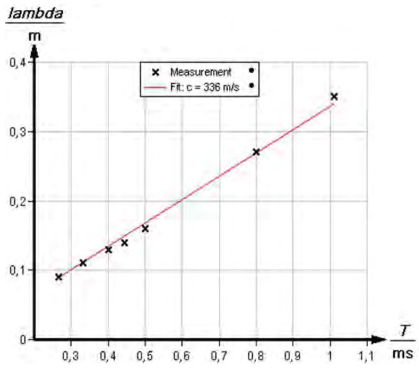
The universal counter is used for measuring time, frequency, pulse rates, pulse counting, periodic times, speeds and velocities.

Benefits

- The device has all the qualities that are expected of a modern universal counter and is also equiped with a number of technical specifics of how it specifically arise from the requirements of science teaching practice.
- For the scientifically correct representation of each measurement is shown in principle with the associated unit. With the overflow of the display is automatically switched into the next area.
- Before the measurement starts it can be manually adjusted to a maximum of 6 decades defined range, e.g. to suppress is not physically meaningful digits on the display.
- A special jack for direct connection of a GM counter tube is available for radioactivity experiments. The required voltage can be changed manually to determine the characteristics of a counter tube too.

13601-99

P2150605 Velocity of sound using Kundt's tube and digital function generator



Determination of the velocity of sound at a tube length of l = 615 mm.

Principle

Cork dust in a glass tube is set into tiniest motion by a sound wave. If the frequency of the sound wave matches the natural frequency of the volume in the glass tube, a standing wave will form. The cork dust then assembles in visible patterns that show the nodes of pressure and motion of the standing wave. From the length of the volume and the number of the nodes the velocity of sound in the tube can be calculated for each natural frequency.

Task

Determine the velocity of sound in air using Kundt's tube at different lengths of volume.

What you can learn about

- Longitudinal waves
- Sound velocity in gases
- Frequency
- Natural frequency
- Wavelength
- Stationary waves

Main articles		
LF amplifier, 220 V	13625-93	1
Digital Function Generator, USB, incl. Cobra4 Software	13654-99	1
Loudspeaker/Sound head	03524-00	1
Tripod base PHYWE	02002-55	3
Kundt's apparatus	03475-88	1
Thermometer -10...+50 C	38034-00	1
Screened cable, BNC, l 750 mm	07542-11	1

Related Experiment

Velocity of sound using Kundt's tube

P2150601

LF amplifier, 220 V

Function and Applications

For amplifying direct and alternating voltage up to 100 kHz. Can be used for induction experiments and for examining acoustic and electromagnetic fields. Signal output for the amplified measured signal.

Benefits

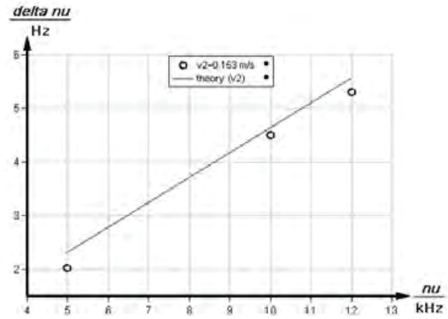
- Effective value output for display of the effective value of the signal output voltage.
- Power amplifier 12.5 W for weak acoustic frequency signals to control low resistance loudspeakers.
- For signals from frequency generators or computer interfaces.
- Amplification is continuously adjustable.

Equipment and technical data

- Ampl. factor: 0.1...10000, continuously adjustable
- Input impedance: 50 kOhm/ AC, 100 kOhm/ D
- Input voltage: -10 V...+10 V; Frequency range: 3.5 Hz....200 kHz,

13625-93

Acoustic Doppler effect with universal counter — P2150405



Comparison of the measured values with calculated values for a detector moving towards the emitter.

Principle
If an emitter of sound or a detector is set into motion relative to the medium of propagation, the frequency of the waves that are emitted or detected is shifted due to the Doppler effect.

Tasks

1. Measure the Doppler shift for varying frequencies and velocities for a moving sound emitter. Compare the measurements with the values predicted by theory and validate equation (4).
2. Measure the Doppler shift for varying frequencies and velocities for a moving detector. Compare the measurements with the values predicted by theory and validate equation (6).

Related Topics

- Wave propagation
- Doppler shift of frequency

Main articles		
Universal Counter	13601-99	1
Digital Function Generator, USB, incl. Cobra4 Software	13654-99	1
Car, motor driven	11061-00	1
Measuring microphone w.amplifier	03543-00	1
Loudspeaker/Sound head	03524-00	1
Light barrier, compact	11207-20	1
Track, l 900 mm	11606-00	1

Car, motor driven

Function and Applications

For the experimental investigation of uniform movements and introduction of the concept of speed.

Benefits

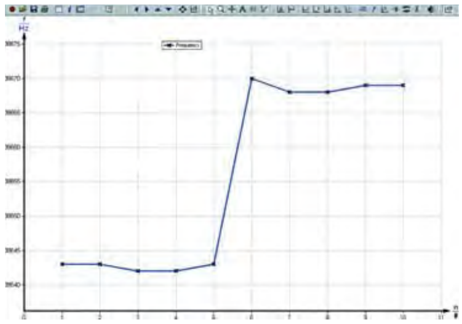
- Drive: integrated battery powered electric motor (with radio noise suppression).
- Sliding switch for continuous speed adjustment; forward and backward switches, 4-wheel drive.
- Recess with clamping spring to attach holding bolt 03949-00.
- Eccentric clamps to attach recording tape for recording timer 11607-00.

Equipment and technical data

- Same chassis as measurement and experimenting car 11060-00.
- Dimensions without wheels (mm): 114×53×64.

11061-00

P2152415 Ultrasonic Doppler effect (with Cobra3)



Doppler shift of frequency.

Principle

If a source of sound is in motion relative to its medium of propagation, the frequency of the waves that are emitted is displaced due to the Doppler effect.

Task

The frequency changes are measured and analysed for different relative velocities of source and observer.

What you can learn about

- Propagation of sound waves
- Superimposition of sound waves
- Doppler shift of frequency
- Longitudinal waves

Main articles		
Cobra3 BASIC-UNIT, USB	12150-50	1
Ultrasound operation unit	13900-00	1
Car, motor driven	11061-00	1
Ultrasonic transmitter	13901-00	1
Ultrasonic receiver on stem	13902-00	1
Light barrier, compact	11207-20	1
Track, l 900 mm	11606-00	1

Cobra4 Experiment - available 2013

Ultrasonic Doppler effect (with Cobra4)

P2152460

Ultrasound operation unit

Function and Applications

Ultrasound operation unit.

Benefits

- Microprocessor controlled quartz-stabilised operation unit for ultrasonic transmitter and receiver.
- Adjustable output amplitude, 2 DIN sockets, one with 180° phaseshift, continuous and burst mode operation.
- 1 synchronous BNC output for delay time measurement.
- Input signal amplifier with 3 main amplifications and fine adjustment with one BNC-socket for oscilloscope.
- Overload warning LED allows adaption of ultrasound intensity to the experiment.
- Ideally suited for ultrasound experiments with large distances between transmitter and receiver, e.g. Doppler-effect with ultrasound.
- Fail-safe housing.

13900-00

About PHYWE

Traditional yet modern
100 years of quality

Those who know nothing must believe everything.

Marie von Ebner-Eschenbach

With a 100-year tradition of excellence, PHYWE Systeme GmbH & Co. KG stands for technical capability, innovation, quality and customer satisfaction. As a leading supplier of premium quality teaching and learning materials, PHYWE is one of the world's largest providers of system solutions for the instruction of the natural sciences.
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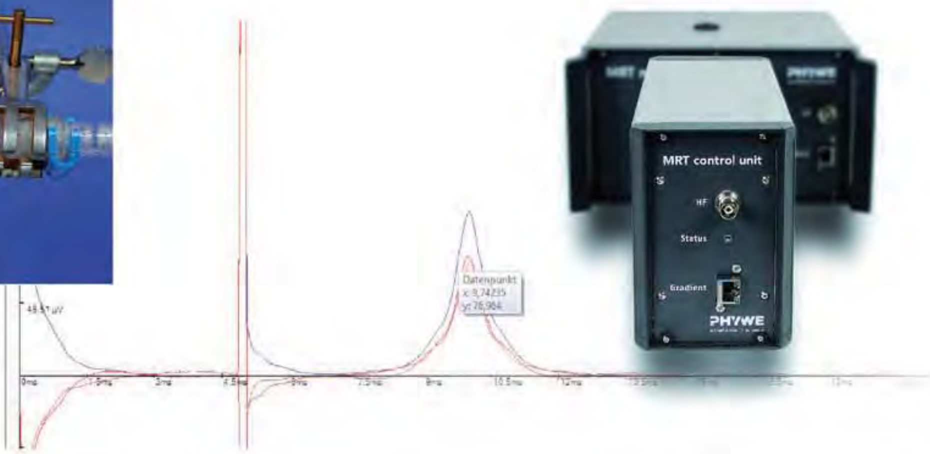
PHYWE

PHYWE supplies more than
50 Nobel Prize awarded experiments

The Nobel Prize is awarded annually in the disciplines of physics, chemistry, physiology or medicine, literature and peace. For scientists and researchers, it is the highest award.

PHYWE supplies more than 50 Nobel Prize awarded experiments. From Conrad Röntgen to Max Planck or Albert Einstein. Experiments in the footsteps of Nobel Prize winners. PHYWE made Nobel Prize experiments understandable.



Nobel Prize awarded experiments (Selection)

1900 ...

1901 – Wilhelm Conrad Röntgen

1901 – Jacobus Henricus van 't Hoff

1902 – Hendrik A. Lorentz, Pieter Zeeman

1903 – Henri Becquerel, Pierre Curie, Marie Curie

1908 – Ernest Rutherford

1909 – Wilhelm Ostwald

1910 ...

1910 – Johannes Diderik van der Wals

1914 – Max von Laue

1915 – Sir William Henry Bragg, Sir William Lawrence Bragg

1912 – F. A. Victor Grignard

1918 – Fritz Haber

1920 ...

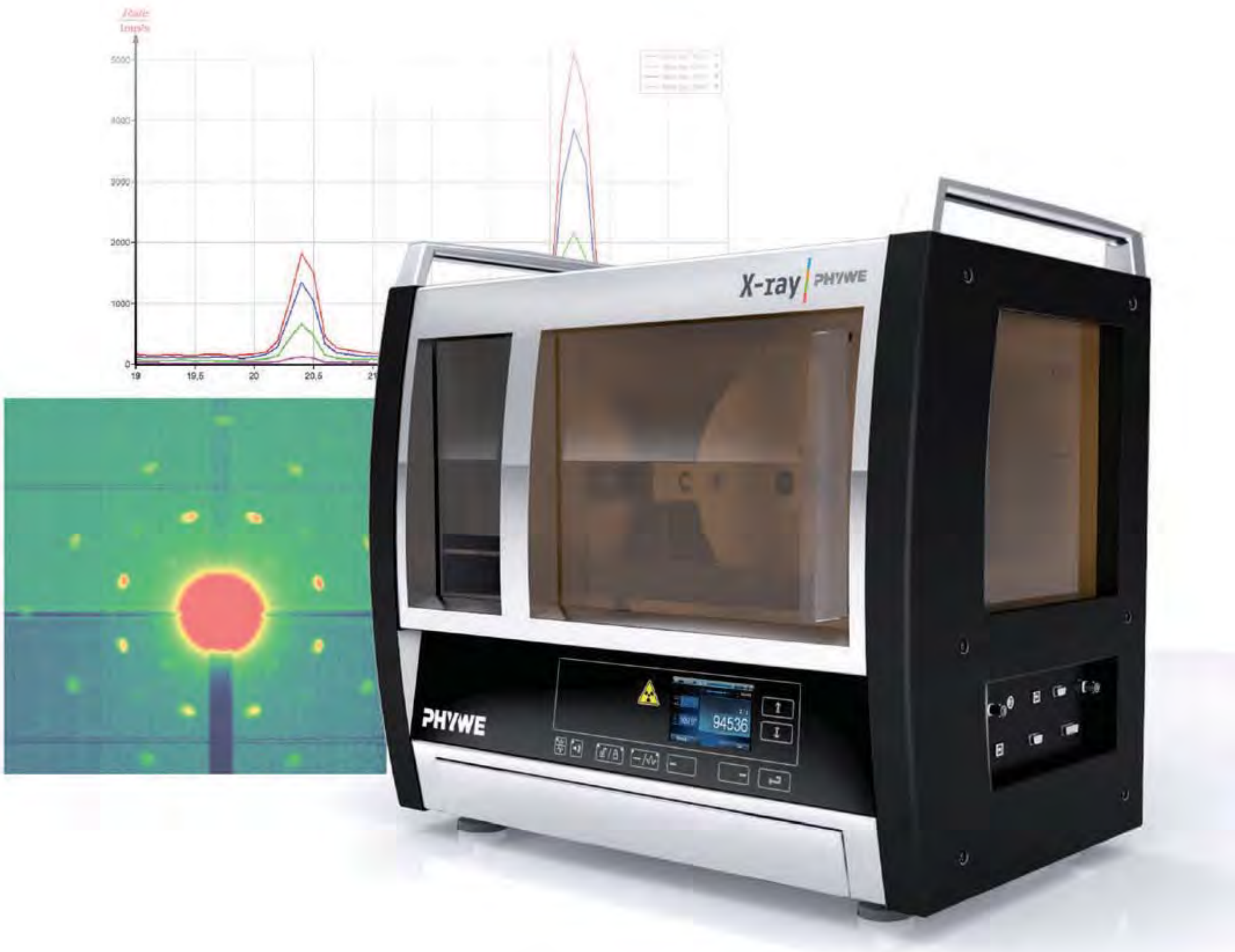
1921 – Albert Einstein

1922 – Niels Bohr, Henrik David

1924 – Manne Siegbahn

1924 – Willem Einthoven

1925 – James Franck, Gustav Hertz



1930 ...

1931 – Carl Bosch, Friedrich Bergius

1932 – Irving Langmuir

1936 – Victor Franz Hess,
Carl David Anderson

1936 – Peter Josephus W. Debye

1940 ...

1943 – Otto Stern

1952 – Felix Bloch, Edward M. Purcell

1952 – Archer John P. Martin,
Richard Laurence M. Synge

1954 – Max Born, Walther Bothe

1970 until today

1971 – Dennis Gabor

1979 – Allan M. Cormack,
Godfrey N. Hounsfield

1986 – Heinrich Rohrer, Gerd Binnig

2003 – Paul C. Lauterbur,
Sir Peter Mansfield

Computer assisted measurement –
for your science experiments

Cobra4 PHYWE

With computer-assisted experiments from PHYWE you rely on a system that perfectly matches the demands of modern scientific education. Approximately 50% of the total number of TESS expert university experiments are computer-based. PHYWE offers the unique Cobra4 system with completely new experimentation possibilities. Be inspired by more than 200 described experiments with Cobra4.

The corresponding software measure stands for simple and reliable data recording, analysis and further processing – and it is available in 24 languages. Get more information about our Cobra4 program in the brochure "Experiments with Cobra4"

Benefits

- wireless measurements – comfortable and modern
- more than 30 sensors for more than 50 measurands
- time-saving: settings can be saved
- fully automatic sensor identification
- up to 99 sensors can be addressed simultaneously
- can be used as a hand-held measuring instrument

Cobra4 Interface System

The Cobra4 interfaces

Wireless measurement with Wireless-Link + Wireless Manager + Remote-Link

For high data rates with the USB-Link

Mobile-Link - even more functions included as of 2013 - no computer necessary

The Cobra4 sensor family

Our roadmap for future products –
Coming up 2013

Cobra4 Sensors

Sound level (12669-00) | **Skin resistance** (12677-00) | **Oxygen** (12676-00) | **Forceplate** (12661-00) | **Colorimeter** (12634-00)

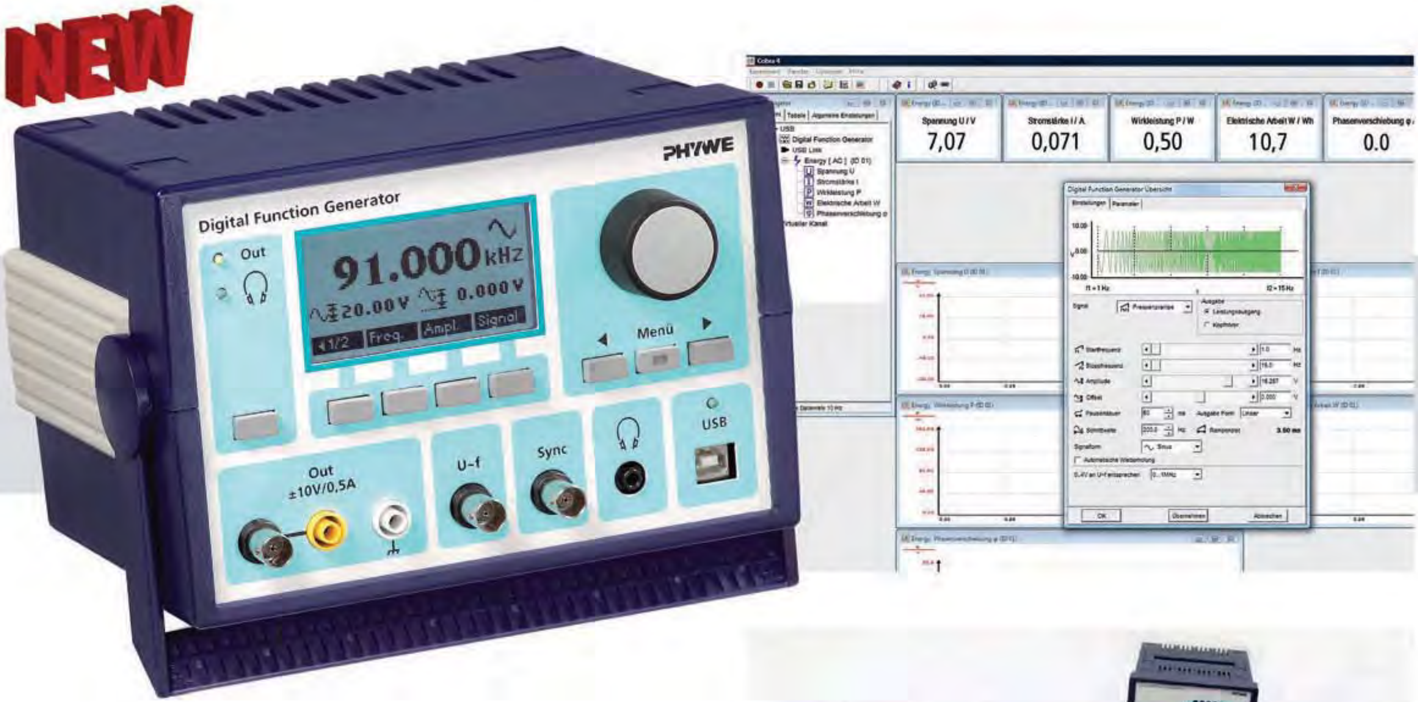
Cobra4 Signal-Link –
The integrated and high accuracy interface for high speed experiments

Features

- Integrated unit of voltage & current sensors + USB interface
- 4 channels (2x current, 2x voltage), electrically isolated
- True RMS converter for all channels
- High resolution: up to 5 microvolts, up to 1 microampere
- Sampling rate: > 1 MHz for current channels and >5 MHz for voltage channels
- Compatible to all Cobra4 equipment

Digital function generator –
universal and intuitive

Cobra4
compatible



Features

- Universal, programmable voltage source with a bandwidth of 1 MHz and an output current of 1 A
- Can be used with Cobra4 or as a stand-alone device
- Intuitive operation via function keys and a rotary control knob
- Illuminated display for optimum visibility
- Low distortion factor and high signal-to-noise ratio for brilliant signals (acoustics/hearing)
- U = U(f) output for a particularly easy pick-up of the frequency – ideal for analysing circuits with frequency ramps
- Part of more than 25 TESS experiments

Faraday effect (P2260106)

Chladni's figures (P2150702)