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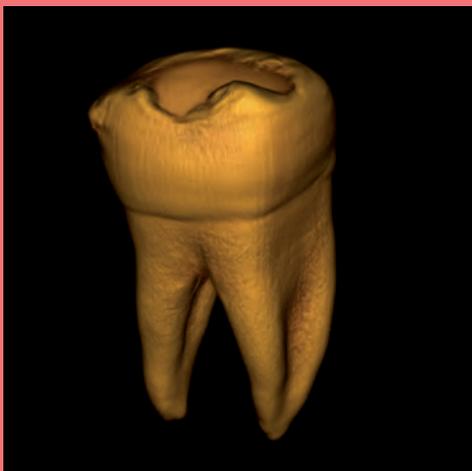
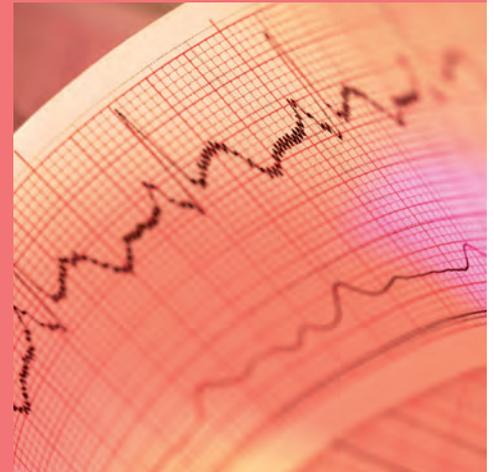
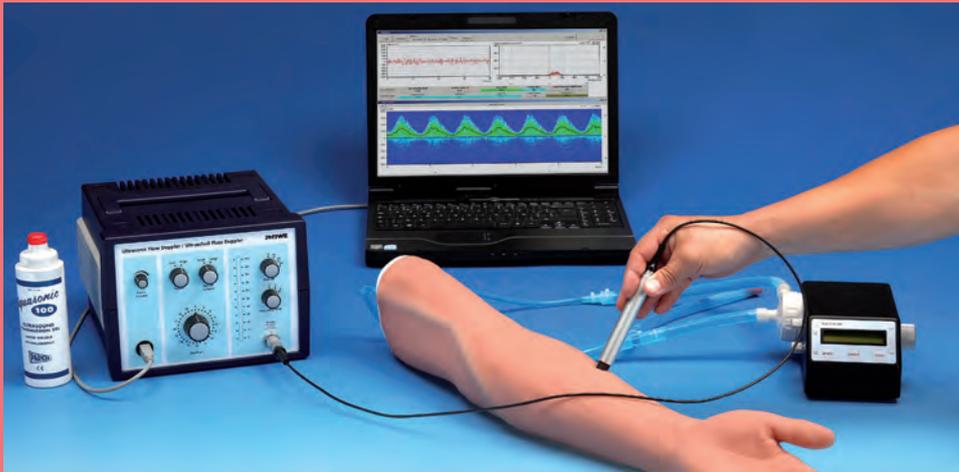
Demo

expert

PHYWE

SEP. 2012

Med



Medicine

University Experiments

Curricula Compliant Experiments – for Preclinical Courses in Medical Doctor Education

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.

Medicine

Preclinical Courses for Medical Students - Reference Curriculum

Content	1. Year			2. Year		
Main Subjects in Tutorials and Laboratory Experiments	Anatomy	Heart and Circulatory System (Chapter 2.1)	Human Physiology (Chapter 2)		Hematology (Chapter 6.3)	Clinical Chemistry (Chapter 6.2)
	Histology (Chapter 7)	Respiration and Pulmonary Diseases (Chapter 2.6)	The Nervous System (Chapter 3)		Radiology and Ultrasonic Diagnostics (Chapter 4)	
		Biochemistry (Chapter 8)		Biomechanics (Chapter 9)	Behaviour (Chapter 2.7)	Nuclear Medicine (Chapter 5)
Subsidiary Subject	Physics *	Biology **		Chemistry ***		
Interdisciplinary Subject	Sociology	Pharmacology	Microbiology (Chapter 7.4)	Genetics		Ethics
Theoretical Courses	Anatomy			Psychology		Immunology
	Development & Disease Mechanisms		Terminology			

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

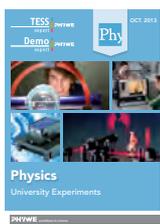
 PHYWE Experiments available

 Anatomic models from PHYWE (Further information at www.phywe.com)

 * Please refer to TESS expert Physics catalogue

 ** Please refer to TESS expert Biology catalogue

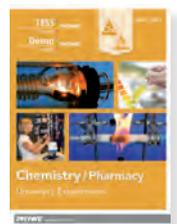
 *** Please refer to TESS expert Chemistry catalogue



TESS expert and Demo expert Physics



TESS expert and Demo expert Biology



TESS expert and Demo expert Chemistry

Curricula Compliant Experiments –

for Medical Assistant Courses and associated Practical Activities



Lab Topic	PHYWE experim.	Chapter in this catalogue
Electrocardiography	✓	2 Human Physiology/ Heart and Circulatory system
Blood pressure, pulse, respiration	✓	2 Human Physiology/Heart and Circulatory system, Respiration and Pulmonary Diseases
Radiology, ultrasound scans	✓	4 Radiology and Ultrasonic Diagnostics
Nuclear medicine	✓	5 Nuclear Medicine
Usage of standard instruments (e.g. photo- meters, coagulometers, centrifuges ...)	✓	6 Laboratory Diagnostics/Standard and Methods, Further Basic Methods
Laboratory procedures, clinical and diagnostic procedures	✓	6 Laboratory Diagnostics
Histology, cytology	✓	7 Histology and Medical Microbiology
Fundamental principles in physics, chemistry and biology	✓	Refer to our catalogues TESS expert and Demo expert Physics, Chemistry and Biology



TESS expert and Demo expert Engineering and Geo Science



TESS expert Medicine

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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.

The product range comprises scientific equipment, experiments and solution systems along with modern blended learning systems, literature and software for the areas of physics, chemistry, biology, medicine, material science and earth science. A broad spectrum of services such as training programmes, installation and comprehensive consulting services completes the portfolio.

PHYWE solutions can be individually adapted to the specific curricula in each country and provide ideal coverage for the full spectrum of performance specifications and requirements. Ask us to prepare a customised equipment offering to suit your special needs!





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:

Article number

11 Biochemistry
11.3 Glycolysis

P4110460 Glycolysis (pressure measurement)



Experimental setup

Description of main principle

Tasks for students

Related scientific topic

List of main articles
Complete list see: www.phywe.com

Pictograms for quick overview

Exemplary measurement result



Variations of the main experiment (e.g. the same experiment with PC-interface) and experiments with similar topics

Devices suitable for the experiment

PHYWE excellence in science

154

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

Computer assisted measurement – for your educational requirements

With computer-assisted experiments from PHYWE you rely on a system that perfectly matches the demands of modern scientific education. The corresponding software **measure** enables simple and reliable data recording, analysis and further processing.

At present, the computer assisted recording of measurement data for TESS expert university experiments - approx 50% of total - are mostly realized with the Cobra3 system. The Cobra3 system will be replaced by Cobra4 until end of 2013. Therefore a significant number of experiments are already based on Cobra4 which are shown in this catalogue. Furthermore all future Cobra4 experiments are clearly displayed aside the relevant topic.

The key advantages of Cobra4

- Wireless measurement data transfer
- Up to 99 sensors can be addressed simultaneously
- Can be used as a hand-held measuring instrument
- Wide range of sensors (30 units)

The Cobra4 interfaces:



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



High data rate
measurement
with the USB-Link



Outdoor
measurement with
the Mobile-Link
(Redesign 2013)

The Cobra4 sensor family

Cobra4 | PHYWE

One of over 30 available sensors

Fast and secure connection of sensors

GPS

SD card for data storage

2,4" Display 65.536 colors

Intuitive operation

USB for charge and data transfer

NEW

Our roadmap for future products –
Coming up 2013

Cobra4 | PHYWE

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



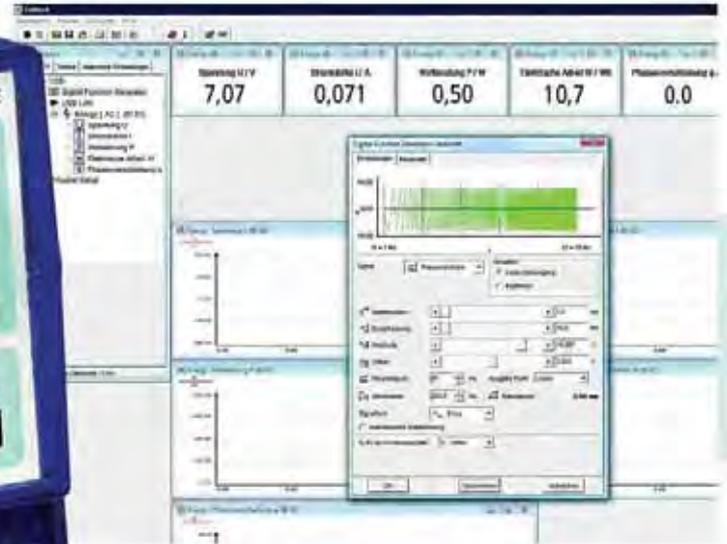
Features

- 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

NEW



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 expert experiments



Human merging frequency and upper hearing threshold (P4040101)



Time resolving capability of the human eye (P4070300)

Curricula Compliant Experiments – for Preclinical Courses in Medical Doctor Education

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

The PHYWE TESS expert medicine programme covers the majority of topics relevant to medical education courses!



Preclinical Courses in Medical Doctor Education – Reference Example

Content	1. Year			2. Year		
Main Subjects in Tutorials and Laboratory Experiments	Anatomy	Heart and Circulatory System (Chapter 2.1)	Human Physiology (Chapter 2)	Hematology (Chapter 6.3)	Clinical Chemistry (Chapter 6.2)	
	Histology (Chapter 7)	Respiration and Pulmonary Diseases (Chapter 2.6)	The Nervous System (Chapter 3)	Radiology and Ultrasonic Diagnostics (Chapter 4)		
		Biochemistry (Chapter 8)	Biomechanics (Chapter 9)	Behaviour (Chapter 2.7)	Nuclear Medicine (Chapter 5)	
Subsidiary Subject	Chemistry *	Biology *	Physics *			
Interdis. Subject	Sociology	Pharmacology	Microbiology (Chapter 7.4)	Genetics		Ethics
Theoretical Courses	Anatomy			Psychology		Immunology
	Development & Disease Mechanisms		Terminology			

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

 PHYWE Experiments available

* Please refer to TESS expert Physics and TESS expert Chemistry catalogues

() Chapter in this catalogue

 Anatomic models

(Further Information at www.phywe.com)



Curricula Compliant Experiments –

for Medical Assistant Courses and associated Practical Activities

Our TESS expert medical programme has been designed to provide a comprehensive educational package for use in medical schools. The experiments are ideally suited to the training of medical and radiological technicians. This brochure shows in detail the practical activities that can be carried out using the equipment and teaching materials offered by PHYWE. Our comprehensive range of experiments greatly simplifies the development of your own training offer through complete sets of equipment fully documented with supporting teaching materials.

Lab Topic	PHYWE experim.	Chapter in this catalogue
Electrocardiography	✓	2 Human Physiology / Heart and Circulatory system
Blood pressure, pulse, respiration	✓	2 Human Physiology / Heart and Circulatory System, Respiration and Pulmonary Diseases
Radiology, Ultrasound scans	✓	4 Radiology and Ultrasonic Diagnostics
Nuclear medicine	✓	5 Nuclear Medicine
Usage of standard instruments (e.g. photometers, coagulometers, centrifuges...)	✓	6 Laboratory Diagnostics / Standards and Methods, Further Basic Methods
Laboratory procedures, clinical and diagnostic procedures	✓	6 Laboratory Diagnostics
Histology, cytology	✓	7 Histology and Medical Microbiology
Fundamental principles in physics, chemistry and biology	✓	Refer to our catalogues TESS expert Physics, Chemistry and Biology



Curricula Compliant Experiments – for your educational requirements

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.

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Curricular topic = main chapter of the catalogue

Curricular subtopic = sub-chapter of the catalogue

Curricular fitting PHYWE experiments

Find the overview of all experiments fitting to the international Reference Curriculum on our homepage!
Click www.phywe.com



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Your solution with just one click!



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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All experiments include computer based measurements with the software **measure** | PHYWE

X-ray Computed Tomography (XRCT)

- Imaging of hard tissue
- Direct digital imaging
- High resolution (48 μm)
- Z-axis sample rotation
- No gravitational effects



Magnetic Resonance

- Imaging of soft tissue
- MRT in compact format
- Suitable for all relevant measuring procedures
- Realtime control of parameters

5 experiments available



PHYWE
excellence in science

Tomography (MRT)



Ultrasonography

- Imaging of soft tissue and dynamic flows
- All relevant measurement techniques are covered
- Ultrasound CT
- Doppler sonography
- Echo-cardiography



6 experiments available



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 laureates. PHYWE makes Nobel Prize experiments understandable.



Nobel Prize awarded experiments (Selection)

1900 ...

- 1901 – Wilhelm Conrad Röntgen
- 1901 – Jacobus Henricus van 't Hoff
- 1902 – Ronald Ross
- 1903 – Henri Becquerel, Pierre Curie, Marie Curie
- 1908 – Ernest Rutherford
- 1909 – Wilhelm Ostwald

1910 ...

- 1911 – Allvar Gullstrand
- 1914 – Max von Laue
- 1915 – Sir William Henry Bragg, William Lawrence Bragg
- 1917 – Charles Glover Barkla
- 1918 – Max Planck

1920 ...

- 1921 – Albert Einstein
- 1924 – Manne Siegbahn
- 1924 – Willem Einthoven
- 1922 – Niels Bohr, Henrik David



1930 ...

- 1930 – Karl Landsteiner
- 1932 – Sir Charles Scott Sherrington, Edgar Douglas Adrian
- 1932 – Irving Langmuir
- 1936 – Victor Franz Hess, Carl David Anderson
- 1936 – Peter Josephus W. Debye

1940 ...

- 1952 – Felix Bloch, Edward Mills Purcell
- 1952 – Archer John Porter Martin, Richard Laurence M. Synge
- 1954 – Max Born, Walther Bothe

1960 until today

- 1971 – Dennis Gabor
- 1979 – Allan M. Cormack, Godfrey N. Hounsfield
- 1986 – Heinrich Rohrer, Gerd Binnig
- 2003 – Paul C. Lauterbur, Sir Peter Mansfield

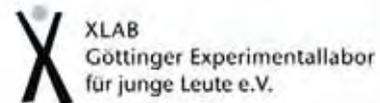
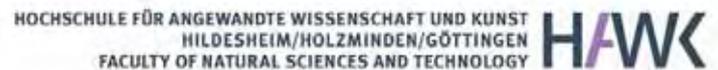
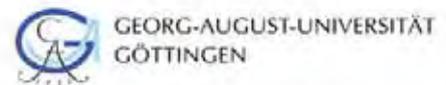
Cooperations – Reliable partner for education

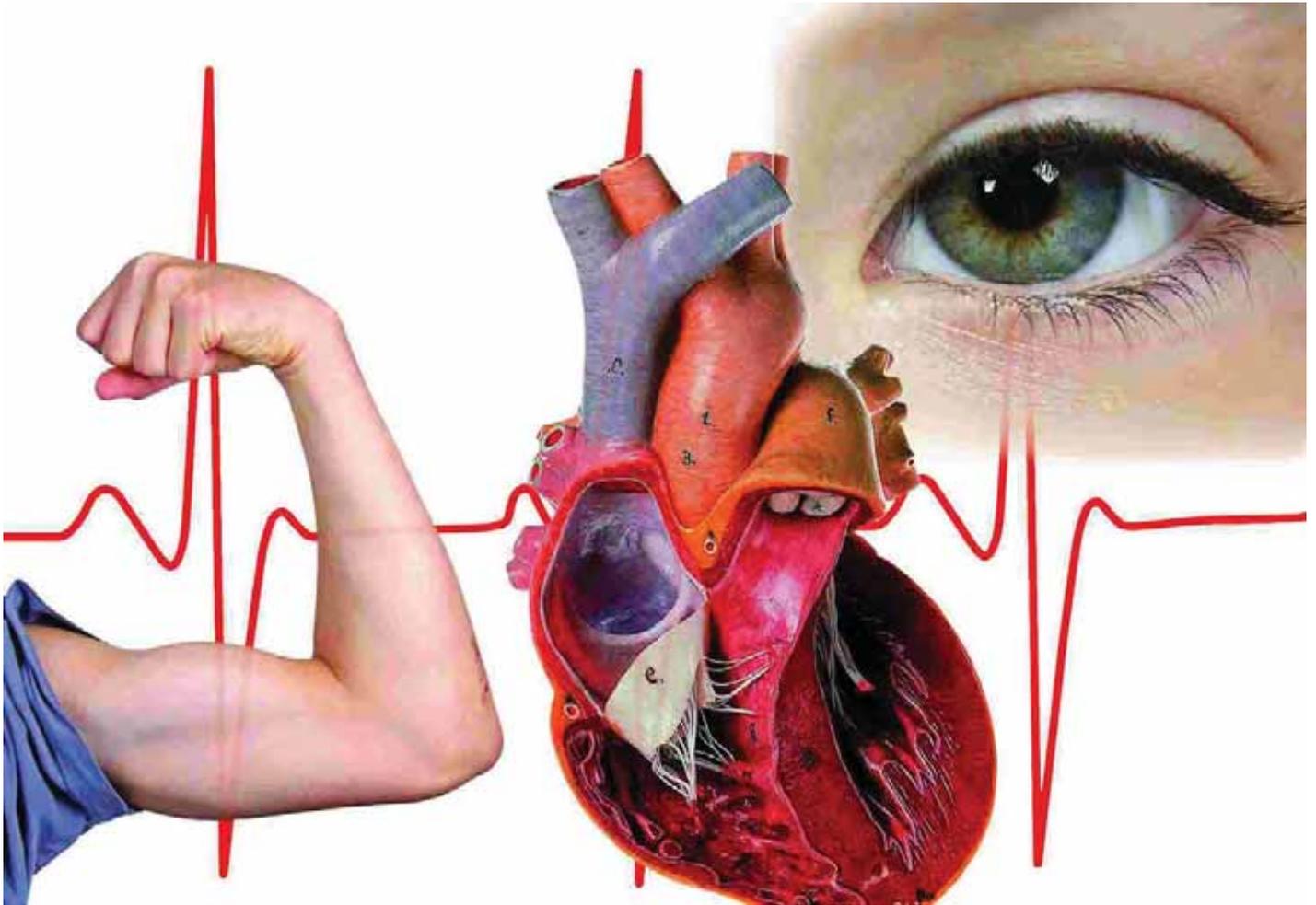
There's a way to do
it better – find it.

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 platform are one by one the result of fruitful cooperation in this regard - thank you!

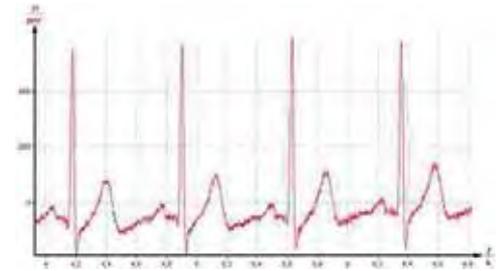




Human Physiology

2.1	Heart and Circulatory System	24
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P4020160 Human electrocardiography (ECG) (with Cobra4)



Electrocardiogram during measurement.

Principle

A typical human electrocardiogram is recorded. The resulting diagram shows all the elements that can be expected in an electrocardiogram: P wave, PR segment, Q wave, R wave, QRS complex, S wave, ST segment and T wave of a normal sinus rhythm for the human heart.

Tasks

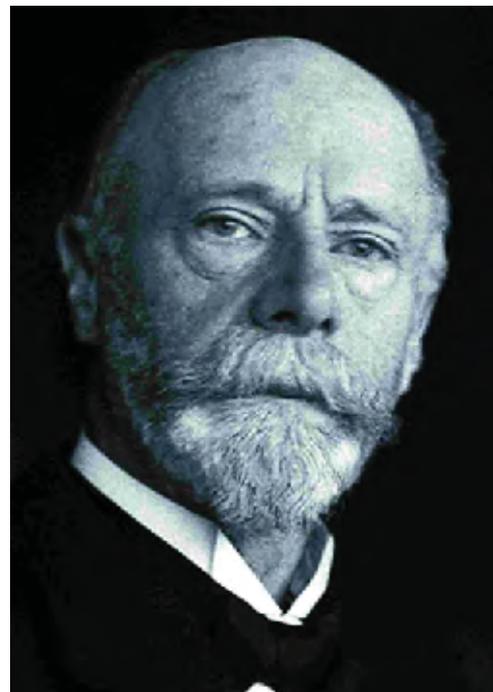
1. Record an electrocardiogram (ECG) between the left leg and the right and left arm (lead II according to Einthoven).
2. Relate the ECG segments to the course of heart contraction (P wave, P-Q segment, QRS complex, T wave).

What you can learn about

- Electrocardiogram according to Einthoven II
- Heart rate
- Quiet and strained heart; ECG segments
- Atria; Ventricles
- AV nodes

Main articles

Software Cobra4 - multi-user licence	14550-61	1
Cobra4 Sensor-Unit Electrophysiology: ECG, EMG, EOG	12673-00	1
Cobra4 USB-Link	12610-00	1
ECG electrodes, 3/pkg	65981-01	1
Shielded leads for electrophysiology, color-coded, 3/pkg	12673-01	1
Potassium chloride 250 g	30098-25	1

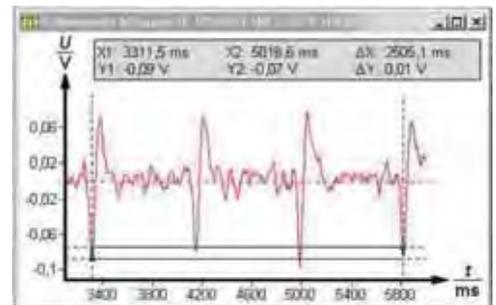
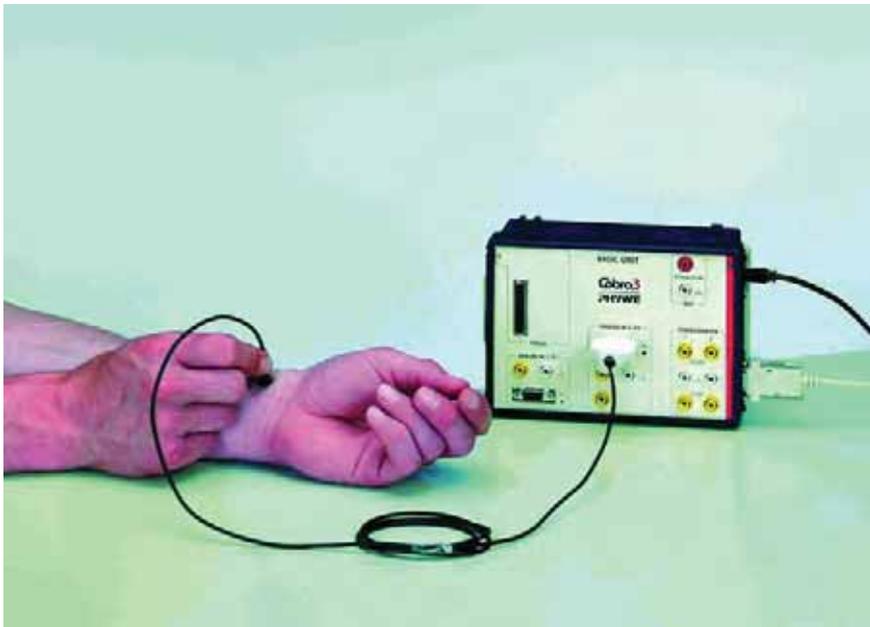


Willem Einthoven

1927, Nobel Prize in Medicine

Phonocardiography: Cardiac and vascular sonic measurement (PCG) (with Cobra3)

P4020211



Typical vascular phonometric measurement.

Principle

With Phonocardiography the sounds of the heart are graphically represented. Cardiac and vascular measurements are recorded at different locations of the circulatory system.

Tasks

1. Cardiac and vascular sonic measurement at different locations of the circulatory system
2. Measurement of the pulse rate at different levels of athletic loading.

What you can learn about

- Pulse
- Throat and chest sonic measurement
- Quiet and strained heart
- Contracting tune
- Systole
- Flapping sound
- Diastole

Main articles

Cobra3 BASIC-UNIT, USB	12150-50	1
Acoustic probe for COBRA3	03544-00	1
Power supply 12V / 2A	12151-99	1
Software Cobra3 Universal recorder	14504-61	1

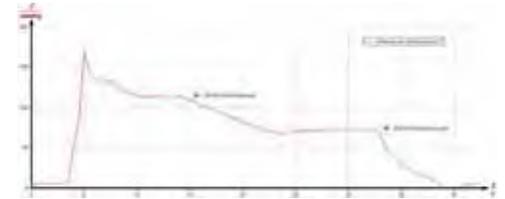
Cobra4 Experiment - available 2013

Phonocardiography: Cardiac and vascular sonic measurement (PCG) (with Cobra4)

P4020260



P4020360 Blood pressure measurement (with Cobra4)



Typical result: The graph shows the three stages of the measurement.

Principle

Didactical blood pressure measurement system for wireless data transfer of measurement data from test person to computer, thereby permitting flexible and mobile experimental setup.

Tasks

To prepare a plot of blood pressure measurement and to read the values of systolic and diastolic blood pressure.

What you can learn about

- Systolic blood pressure
- Diastolic blood pressure
- Measuring cuff
- Blood pulse waves

Main articles

Software Cobra4 - multi-user licence	14550-61	1
Cobra4 Sensor-Unit Thermodynamics	12638-00	1
Cobra4 USB-Link	12610-00	1
Blood pressure measuring unit	64234-00	1

Valves of the veins, working model



Function and Applications

Functional working model consisting of a transparent tube made of acrylic glass to simulate the function of the valves in an air stream.

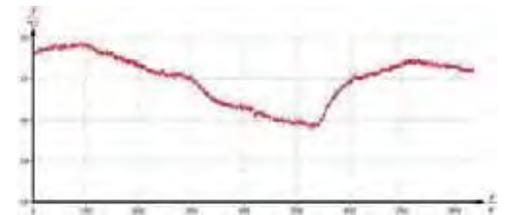
Benefits

- Instead of the blood stream a stream of air is generated.
- Demonstrate the flow of blood in the opening flap and the back pressure, which is formed when the flaps are closed automatically by the pressure of the blood.

87071-00

Changes in the blood flow during smoking (with Cobra4)

P4020460



Change in the skin temperature during smoking.

Principle

Cigarette consumption influences the diameter and therefore the circulation of the peripheral blood vessels. This experiment studies the change of the finger temperature during smoking.

Tasks

How the temperature curve differs should be discussed with reference to the tested persons' regular smoking habits.

What you can learn about

- Skin temperature
- Heavy and moderate smokers
- Occasional smokers
- Non-smokers

Main articles

Software Cobra4 - multi-user licence	14550-61	1
Cobra4 USB-Link	12610-00	1
Cobra4 Sensor-Unit Temperature, semiconductor -20...110 °C	12640-00	1

Blood circulation, functional model



Function and Applications

Functional working model of blood circulation.

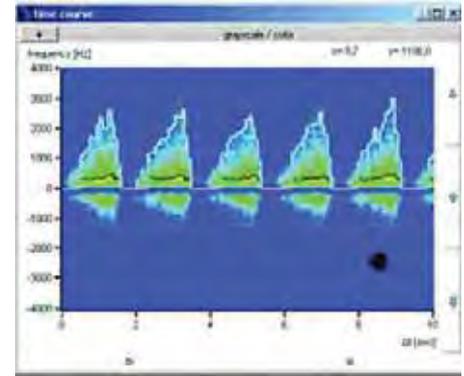
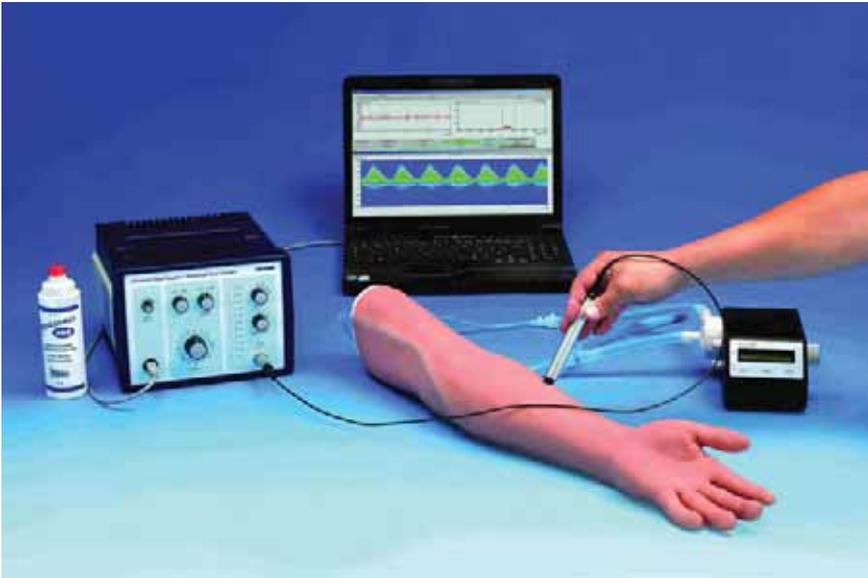
Equipment and technical data

Components:

- heart
- lung
- arteries
- veins
- capillary system
- material: acrylic glass and silicone filled with coloured liquid
- dimensions: on a stand 35x37 cm

87073-00

P5950100 Doppler sonography



Typical spectral window pump mode 4 measured with PHYWE measure Ultra Flow software.

Principle

This set-up shows how blood flow studies are performed using Doppler ultrasound (Doppler sonograph). On a realistic arm dummy, the differences between continuous (venous) and pulsating (arterial) flow are shown as well as the difference in flow through a normal blood vessel and a stenosis.

Tasks

1. Analyse blood flow and search positive and negative flow components. Explain the differences
2. Locate the built-in stenosis and compare the spectral distribution upstream and downstream of the stenosis
3. Examine and compare the three pulse modes of the pump.

What you can learn about

- Venous flow
- Arterial flow
- Stenosis
- Blood flow velocity tracings
- Frequency shift
- Doppler effect
- Doppler angle
- Doppler sonography
- Colour Doppler
- Continuity equation

Main articles

Basic set: Ultrasonic Doppler technique	13923-99	1
Extension Set: medical Doppler Sonography	13923-02	1

Related Experiment

Ultrasonic Time Motion Mode

P5950200

Extension Set: medical Doppler Sonography



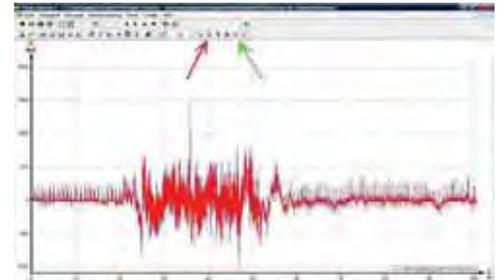
Function and Applications

A realistic arm model is used to simulate the application of the Doppler effect in medicine. With a Doppler sonography the influence of a stenosis on the flow profile can be investigated. A pump generates different flow types (continuous and pulsatile) and can simulate the human blood circulation. The measured Doppler signals can be presented acoustically as well as in a colour-coded Doppler spectrum. The results and images are similar to measurements of those on patients.

13923-02

We investigate our physical fitness - the heart under stress (with Cobra4)

P1522160



ECG under strain from 20 squats.

Principle

An electrocardiogram (ECG) can record the sum of the electrical activities of all of the heart muscle fibres. Under stress, cardiac activity increases in order to maintain the stability of the cardiovascular system. The heart contraction cannot be controlled at will. This experiment enables you to study how physical stress affects the respective activity of your heart.

Tasks

1. Record an ECG while switching from rest to strain (20 squats)
2. Record an ECG while switching from strain to rest and calculate the time that elapses until the resting heart rate is reached again

What you can learn about

- Electrocardiogram (ECG)
- Cardiac activity
- Heart muscle

Main articles

Software Cobra4 - multi-user licence	14550-61	1
Cobra4 Sensor-Unit Electrophysiology: ECG, EMG, EOG	12673-00	1
Cobra4 Wireless-Link	12601-00	1
Cobra4 Wireless Manager	12600-00	1
Shielded leads for electrophysiology, color-coded, 3/pkg	12673-01	1
Electrodes for ECG Sensor, 100 pcs.	12559-01	1

Cobra4 Sensor-Unit Electrophysiology: ECG, EMG, EOG



Function and Applications

To perform electrophysiological, noninvasive, measurements of heart, eye and muscle activities.

Benefits

- The measurement electrodes are connected to 3,5 mm jacks using three separate and shielded measurement cords.
- Requires measurement cords and ECG and/or EMG/EOG electrodes.

12673-00

2 Human Physiology

2.1 Heart and Circulatory System

TESS advanced Applied Sciences set Electrophysiology, EP with english manual



Function and Applications

Complete instrument set and accessories to perform computer-assisted experiments in human and animal physiology:

- The heart/ ECG (3 exp.)
- Muscles/ EMG (1 exp.)
- The eye/ EOG (3 exp.)

Benefits

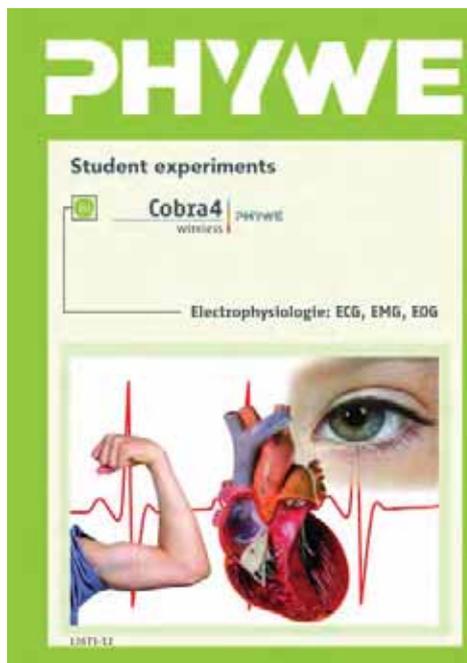
- Wireless transmitter and receiver units to connect the electrophysiology sensor to a PC, can also be used for other sensors to measure parameters common in physics, chemistry, biology and medical education

Equipment and technical data

- Electrophysiology sensor-unit for ECG, EMG and EOG with connectors for three measurement leads
- 3 separate and shielded leads, color-coded (red, yellow, green) with 3.5 mm phone jacks to connect to the sensor-unit and 2 mm jacks to connect to reusable and disposable electrodes
- 3 reusable stainless steel ECG electrodes, contact area 30 x 80 mm with connector for leads
- 3 reusable EMG electrodes with cable and 2 mm connectors
- Disposable electrodes (100 pcs.)
- 3 crocodile clips for disposable electrodes
- Electrode gel to improve contact between electrodes and skin
- Software for wireless and wired data acquisition, for data analysis, automatic sensor recognition, automatic setup of measurement parameters and integrated experiment instructions
- 68-page manual with experimental literature
- Storage box for instrument set and accessories

12673-89

TESS advanced Biology manual Cobra4 Electrophysiology: ECG, EMG, EOG



Description

Manual with 7 student experiments in the field of electrophysiology (ECG, EMG, EOG) for data acquisition with the wireless interface system Cobra4.

Topics

- We investigate our heartbeat (Electrocardiography)
- We determine our heart frequency
- We investigate our physical fitness (the heart under strain)
- We investigate our muscular power (Electromyography)
- We investigate our eye movements (Electrooculography)
- We measure our reading speed
- Electronystagmography

Benefits

- The students are enabled to carry out the experiments by themselves and to work on the topic of electrophysiology self-dependently.

Equipment and technical data

- Student sheets and corresponding teacher sheets
- In colour, 68 pages, incl. manual on software installation and handling.

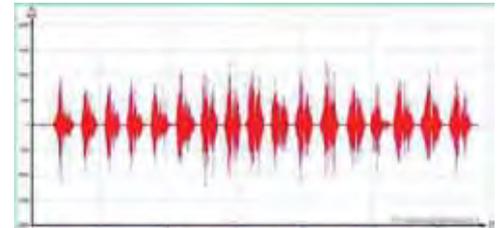
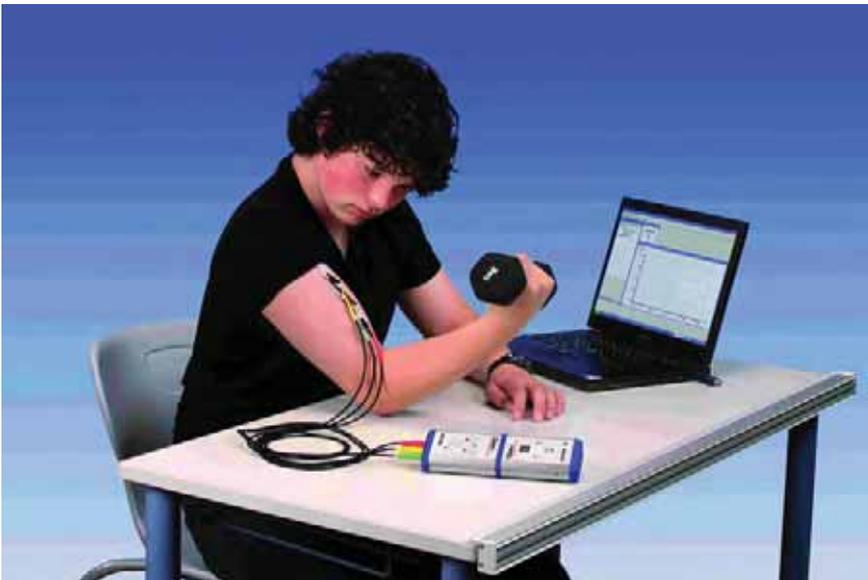
12673-12

You need more information? WEB@ PHYWE
Just click www.phywe.com



Electromyography (EMG) on the upper arm (with Cobra4)

P4030160



Compound action potentials of the biceps under load by 5-kg dumbbells.

Principle

With the exception of the heart muscle, the contractions of striated muscles can be controlled at will. This characteristic enables the observation of the activities of individual muscle groups. An electromyogram (EMG) can be used to measure (record) the electrical activity (i.e. the sum of the action potentials) of a muscle or even of several muscles on the skin surface when they contract. For an electromyogram, the electrical activity of a muscle is recorded in the relaxed state as well as during contractions of varying strength.

Tasks

1. To prepare an electromyogram (EMG) from a contracting or relaxing upper arm muscle (biceps) using surface electrodes.
2. Measurement of the frequency and the amplitude of the EMG at maximum concentration.

What you can learn about

- Electromyogram
- Muscle contractions
- Biceps
- Muscle potentials
- Compound action potentials

Main articles

Software Cobra4 - multi-user licence	14550-61	1
Cobra4 Sensor-Unit Electrophysiology: ECG, EMG, EOG	12673-00	1
Cobra4 USB-Link	12610-00	1
Shielded leads for electrophysiology, color-coded, 3/pkg	12673-01	1
Electrodes for ECG Sensor, 100 pcs.	12559-01	1

Software Cobra4 - multi-user licence



Function and Applications

The "measure Cobra4" measuring software leaves nothing to be desired.

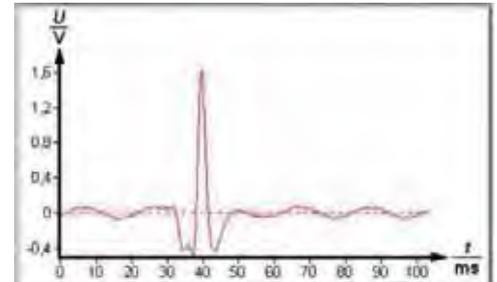
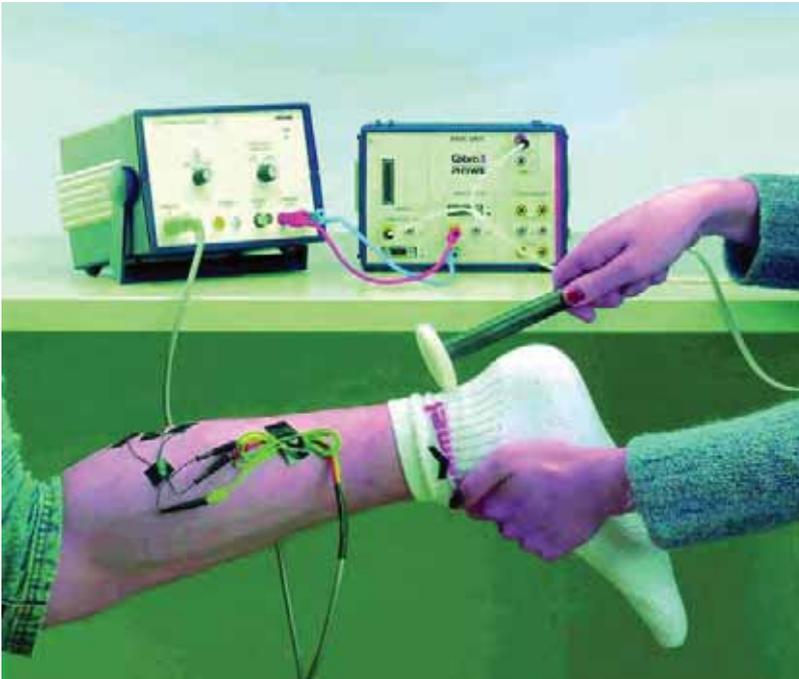
As soon as a Cobra4 sensor is connected to a PC, irrespective of whether by Cobra4 Wireless or Cobra4 USB Link, the "measure Cobra4" software opens completely automatically and shows the connected sensors, the required measuring windows and the current measuring data.

Measurement recording is then started with a single CLICK.

This all takes under 40 seconds!

14550-61

P4030211 Muscle stretch reflex and determination of the conducting velocity (with Cobra3)



The reflex latency is approximately 40 ms. With a nerve tract length (Achilles tendon - spinal cord - muscle) of 2 m, the conduction velocity is 50 m/s.

Principle

Tapping the Achilles tendon stretches the calf muscle and causes a reflex contraction in the muscle. This happens because the spindles sense the stretch and send an action potential to the motor neurons which then cause the muscle to contract. The amplitude of the muscle action potential is higher with tensed arm musculature than with relaxed arm musculature (approx. 3 mV compared to approx. 2 mV). The cause of this so-called Jendrassik effect is that, as a result of the tensing of the arm musculature, the other motoneurons of the spinal cord are innervated (facilitation).

Tasks

1. Trigger a stretch reflex in the lower leg musculature by tapping the Achilles tendon (Achilles tendon reflex)
2. Record the compound action potential and determine the reflex latency and the conduction velocity.

What you can learn about

- Electromyogram; Muscle stretch reflex
- Achilles tendon; Reflex latency
- Conduction velocity; Jendrassik effect; Facilitation

Main articles

Cobra3 BASIC-UNIT, USB	12150-50	1
Biological amplifier	65961-93	1
Reflex hammer, triggering	65981-10	1
Electrode commoning cable	65981-03	1
EMG electrodes, 3 off	65981-02	1
Power supply 12V / 2A	12151-99	1
Software Cobra3 Universal recorder	14504-61	1

Cobra4 Experiment - available 2013

Muscle stretch reflex and determination of the conducting velocity (with Cobra4)

P4030260

Biological amplifier



Function and Applications

With the aid of this biological amplifier a wide range of electrophysiological experiments can be carried out on human beings, insects and earthworms.

The frequency range for the measurement can be preselected to match the different biological current sources as in ECG, EMG, EEG, EOG, ENG.

65961-93

Human merging frequency and upper hearing threshold

P4040101



goldfish	up to 4 kHz
frog	30 Hz to 15 kHz
chaffinch	200 Hz to 29 kHz
cat	up to 50 kHz
bat	up to 90 kHz
whale	up to 150 kHz

Animals also have a typical hearing range, and even vertebrates may have ranges differing very considerably from the human range.

Principle

The hearing range of the human depends greatly on age. While tones above the upper acoustic threshold are not perceived at all, individual sounds under the lower hearing threshold are perceived as a continuous deep tone (merging).

Tasks

1. Determine the merging frequency and upper acoustic threshold of test subjects of various ages.
2. Stimulate the ear with tones at the lower and upper acoustic threshold using a sine wave generator and headphones.

What you can learn about

- Acoustic hearing thresholds
- Merging frequency
- Hearing range
- Sine wave generator

Main articles

Digital Function Generator, USB, incl. Cobra4 Software	13654-99	1
Headphone, stereo	65974-00	1



Digital Function Generator, USB, incl. Cobra4 Software



Function and Applications

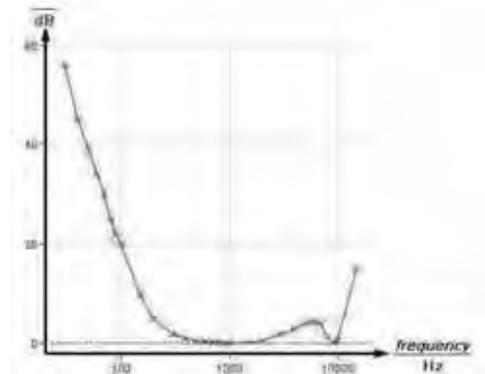
Digital signal generator for use as a programmable voltage source in practical or demonstration experiments, particularly in the disciplines of acoustics, electrical engineering and electronics

Benefits

- Can be used as universal stand-alone device or controlled via a USB interface
- Universally applicable thanks to broad, continually adjustable frequency range
- Usable as programmable voltage source via amplifier output
- Intuitive, menu-driven operation using control knob and function buttons, with help capability
- Illuminated monochrome graphic display for maximum visibility and readability
- Simple setting of voltage and frequency ramps in stand-alone mode
- Features $V = f(f)$ output for easy reading of frequency in the form of a voltage - ideal for measuring circuit response to frequency ramps using an oscilloscope
- Low distortion and signal-to-noise ratio for brilliantly clear signals - ideal for acoustics/audio experiments

13654-99

P4040215 Hearing threshold and frequency differentiating threshold in humans (with Cobra3)



Hearing threshold curve.

Principle

The hearing threshold is the minimum sound level of a pure tone that one can perceive. It depends on the frequency range investigated. The frequency differentiation threshold is the frequency difference between two sounds of the same intensity which can just still be perceived as two different sounds.

Tasks

1. Determine the hearing threshold for a number of frequencies in the hearing range of humans and plot a hearing threshold curve.
2. Determine the frequency differentiation threshold at different starting frequencies. Plot a curve of the frequency differentiation threshold.

What you can learn about

- Hearing thresholds curve
- Frequency differentiation threshold
- Hearing range

Main articles

Digital Function Generator, USB, incl. Cobra4 Software	13654-99	1
Cobra3 BASIC-UNIT, USB	12150-50	1
Headphone, stereo	65974-00	1
Power supply 12V / 2A	12151-99	1
Software Cobra3 Universal recorder	14504-61	1
Screened cable, BNC, l 250 mm	07542-10	1
Adapter, BNC socket/4 mm plug pair	07542-27	2

Functional Ear Model



Function and Applications

Demonstrate to your students how the tympanic membrane, ossicles, cochlea, and the oscillations of the basilar membrane operate and interact with each other. These anatomical structures are all encased in a water-filled chamber and a miniature hammer is mounted on the outside of the model. When the hammer strikes the model, students can observe how the water waves travel through the model and relate that to how sound waves travel in the ear. A mirror is strategically attached in order to observe various ear functions from many different angles.

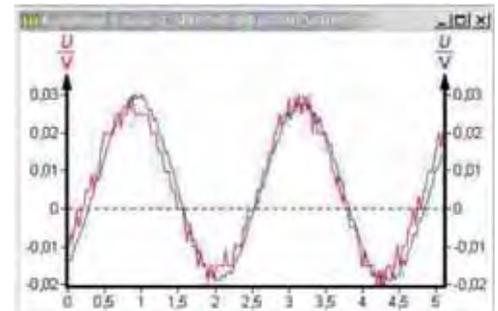
Equipment and technical data

- The model comes with instructions and an explanatory chart as well
- Size: 26,4 x 15,8 x 13,2 cm

87913-00

Acoustic orientation in space (with Cobra3)

P4040311



Result for 0 degrees.

Principles and tasks

To localize a source of sound using an artificial head. To measure the time difference and the difference in intensity of the sound waves incident on each ear of the artificial head.

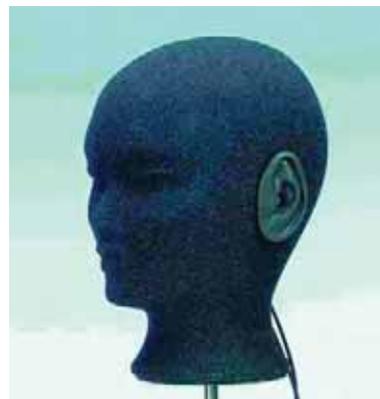
What you can learn about

- Spatial orientation
- Artificial head
- Acoustic probes
- Threshold angle
- Travelling time difference

Main articles

Cobra3 BASIC-UNIT, USB	12150-50	1
Artificial head w/o microphones	65975-01	1
Tripod base PHYWE	02002-55	1
Protractor scale with pointer	08218-00	1
Tuning fork, 440 Hz, on reson.box	03427-00	1
Acoustic probe for COBRA3	03544-00	2
Power supply 12V / 2A	12151-99	1
Software Cobra3 Universal recorder	14504-61	1

Artificial head



Function and Applications

For the demonstration of binaural (spatial) hearing and for measurement of the threshold angle.

Benefits

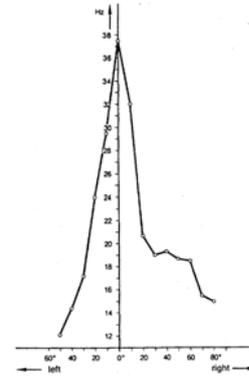
- Highly sensitive microphones can be positioned in the ears, which are faithful copies of the natural ones
- The microphones can be connected to the two amplifier inputs of a computer interface or storage oscilloscope. (Neither the tripod nor the microphones are included in the equipment supplied).

Equipment and technical data

- Head made of styropor, anthrazit
- Ears made of gum

65975-01

P4070300 Time resolving capability of the human eye



Flicker fusion frequency curve.

Principle

As excitation of the light-perceptive cells of the retina, always takes a little longer than the light stimulus, only a limited number of stimuli per unit of time can be processed (time-related resolving power of the eye). If a light source is switched on and off periodically in increasingly rapid sequence the eye at first perceives the individual flashes, then the appearance of flicker occurs and finally the impression of a continuous light (fusion of the flicker).

Tasks

1. Determine the flashing frequency of an LED at which the impression of a continuous light just occurs
2. Change the direction of incidence of the light using a perimeter
3. Determine the flicker fusion threshold of the left and right eye in relation to the direction of incidence of light stimulus and the state of adaptation of the eyes.

What you can learn about

- Perimeter; Time-related resolving power
- Flicker fusion frequency; Light/dark adapted eye

Main articles

Digital Function Generator, USB, incl. Cobra4 Software	13654-99	1
Perimeter, diameter 60 cm	65984-00	1
Stimulant light source	65985-00	1

Related Experiments

Determination of the human visual field

P4070200

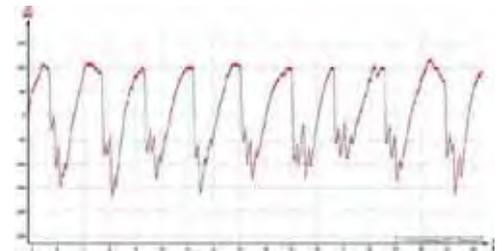
Additive colour mixing and colour masking

P4070600



Electronystagmography (ENG) (with Cobra4)

P4070760



Electronystagmogram of the eye movement during the observation of repetitive stripes on a rotating drum.

Principle

Electronystagmography (ENG) is an electrophysiological diagnostic procedure for measuring the movement of the eyes. Several electrodes measure the potential differences that are caused by the eye movements.

When looking at a moving, regular, repetitive pattern (e.g. the wagons of a passing train, stripes on a rotating drum), the eyes usually try to follow one point for as long as possible. When the object that the eyes are fixed on leaves the field of vision, the eyes then move rapidly in the opposite direction (regressive saccade) and seek a new fixation point.

Tasks

Record an electronystagmogram of your eye movements while looking at the stripes on a rotating drum.

What you can learn about

- Electronystagmography (ENG)
- Movement of the eye
- Nystagmus

Main articles

Software Cobra4 - multi-user licence	14550-61	1
Cobra4 Sensor-Unit Electrophysiology: ECG, EMG, EOG	12673-00	1
Cobra4 Wireless-Link	12601-00	1
Strobe drum	65976-00	1
Power supply 0...12 V DC/ 6 V, 12 V AC, 230 V	13505-93	1
Motor, with gearing, 12 VDC	11610-00	1
Cobra4 Wireless Manager	12600-00	1

Strobe drum



Function and Applications

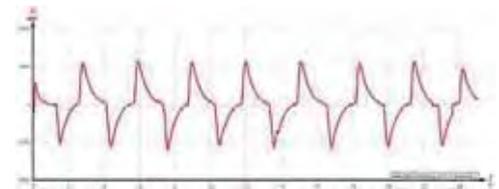
To produce moving stimuli for the investigation of the resolving power of the eye, for testing human reaction capacity and as a type of centrifuge for investigating the effects of mass acceleration on plants and animals.

Equipment and technical data

- Diameter: 32 cm
- Circumference: 100 cm
- Height: 20 cm
- Pattern: 180 black stripes
- With drive belt

65976-00

P4070560 Human electrooculography (EOG) (with Cobra4)



Electrooculogram (alternating eye movements from the left to the right, and vice versa).

Principle

With this experiment, you can find evidence of the electrical activity that is generated during the movement of your eyes. Several electrodes attached to the skin of the face measure all the changes of the electrical voltage that are caused by the movement of the eyes. This method is referred to as electrooculography (EOG).

Tasks

1. Measure an electrooculogram (EOG) with a practised reader, a less practised (six year old) schoolchild and if possible, a test person who practices a rapid reading technique
2. Evaluate the rapid horizontal eye movements (sacchades) and the fixation periods.

What you can learn about

- Electrical field measurement
- Eye movements
- Dipole
- Sacchades
- Fixation period
- Practised reader versus schoolchild
- Rapid reading techniques

Main articles

Software Cobra4 - multi-user licence	14550-61	1
Cobra4 Sensor-Unit Electrophysiology: ECG, EMG, EOG	12673-00	1
Cobra4 USB-Link	12610-00	1
Shielded leads for electrophysiology, color-coded, 3/pkg	12673-01	1
Electrodes for ECG Sensor, 100 pcs.	12559-01	1

Human eye, working model



Function and Applications

This model is a mechanical copy of an eyeball.

66650-00

Eye with variable lens, working model



Function and Applications

Eye lens as a function of variable model. It shows the adaptability of the human lens for distance and near vision. The eyeball can be decreased or extended. A picture can be projected on the "retina" and corrected by supplementary lenses.

87037-00

P2210200**Law of lenses and optical instruments**

For more details refer to www.phywe.com

Principle

The focal lengths of unknown lenses are determined by measuring the distances of image and object and by Bessel's method. Simple optical instruments are then constructed with these lenses.

P0872200**Detection of accommodation with an optometer**

For more details refer to www.phywe.com

Principle

When looking through a slide with two very small holes located very close together (optometer aperture), in the absence of accommodation relative to their distance, objects close to the eye appear to be relatively well focussed except that there appear to be two of them. This makes it easy to demonstrate whether a person's eye is accommodating properly (single image) or not (double image). Focussing on the more distant needle makes the nearer needle appear twice. Focussing on the closer needle means the more distant needle appears to be doubled.

P0872500**Subjective colour mixing with the colour wheel**

For more details refer to www.phywe.com

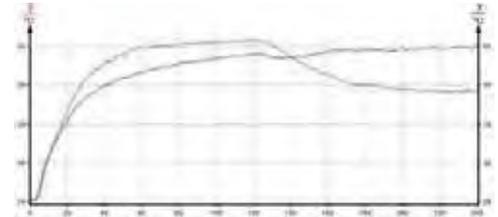
Principle

If a circular disc separated into various differently coloured sectors is rotated by a motor so fast that the eye can no longer distinguish the colours, a mixed colour is then perceived. By varying the composition and size of the sectors, it is possible to give the impression of any colour at all. The colour triangle can be used to predict what the perceived colour will be.

Tasks

Cause the perception of a mixed colour or of white with the help of rotating coloured discs with 2 to 8 sectors of various colours.

P4060360 Regulation of human body temperature (with Cobra4)



Regulation of the human body temperature through external influences.

Principle

How can our body temperature be regulated? This experiment shows why we sweat in summer and wear gloves in winter.

Tasks

1. To prepare curves demonstrating the regulation of body temperature.
2. To discuss different curves depending on the conditions at the hand of the test person.

What you can learn about

- Body temperature regulation
- Radiation
- Evaporation
- Skin temperature
- Heating/cooling effects

Main articles

Software Cobra4 - multi-user licence	14550-61	1
Cobra4 USB-Link	12610-00	1
Cobra4 Sensor-Unit Temperature, semiconductor -20...110 °C	12640-00	1
Hot/cold air blower, 1800 W	04030-93	1

Cobra4 USB-Link



Function and Applications

The Cobra4 USB-Link is a highly efficient interface module for the transmission of sensor measuring values to a PC via a USB connection.

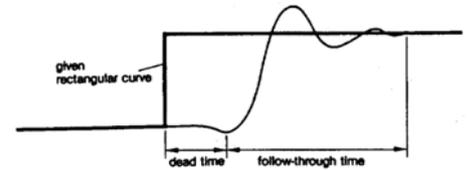
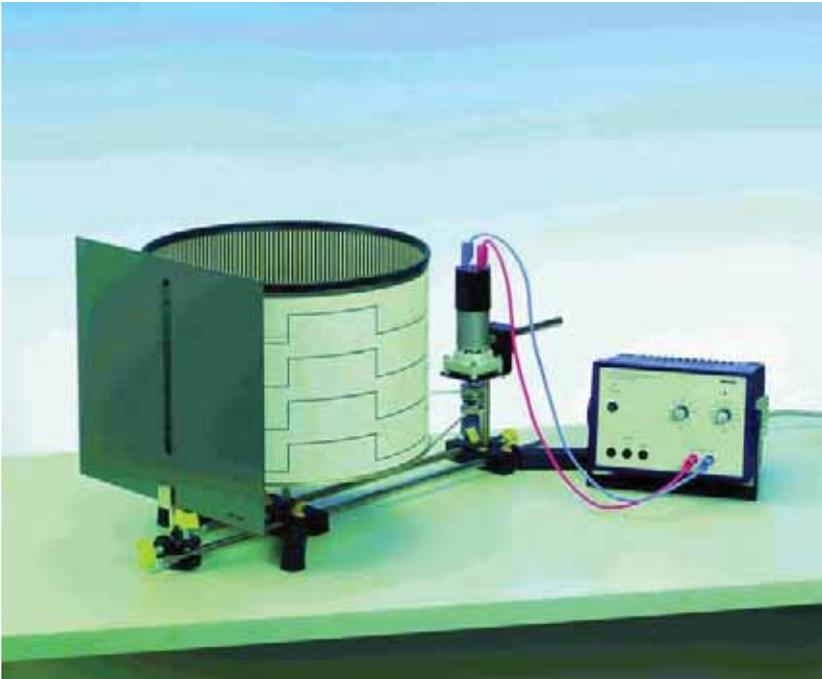
Benefits

- All Cobra4 Sensor-Units can be connected to the Cobra4 USB-Link using a stable plug-in / lockable connection.
- Up to 400,000 measuring values/sec
- Several Cobra4 USB links can be connected to one PC (via USB ports on the PC or by USB hub)
- Automatic detection of all Cobra4 Sensor-Units
- Power supply from USB connection, no additional external power supply required

12610-00

Test of human reaction capacity

P4070400



Reaction curve.

Principle

As in many technical processes, in the course of many biological functions the output values act back on the input values. With the many disturbing influences that affect biological systems, a feedback reaction (control loop) of this type enables an equilibrium to be established. The components of a biological control loop (receptors, neurones, synapses, effectors) require a certain time for the transmission of a signal. This time between the onset of a disturbance (stimulus) and the reaction which it triggers is called the dead time. In this experiment the test subject follows a rectangular curve on a slowly rotating drum, using a felt-tip pen inserted into a slit. In a reaction test the dead time is determined.

Tasks

1. Measurement of dead time in a reaction test
2. Analysis of the transient response
3. Determination of threshold frequency for stimuli
4. Study of the effects of noise and alcohol on reaction capacity.

What you can learn about

- Reaction capacity
- Strobe drum
- Control loop
- Feedback reaction
- Dead time
- Follow-through time
- Threshold frequency

Main articles

Strobe drum	65976-00	1
Power supply 0...12 V DC/ 6 V, 12 V AC, 230 V	13505-93	1
Motor with disk holder	11614-00	1

Power supply 0...12 VDC/ 6 V, 12 VAC, 230 V



Function and Applications

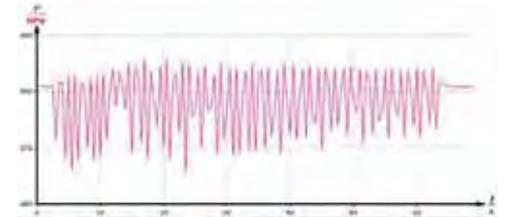
High quality power supply specially suitable for student experiments in electricity and electronics as well as for demonstration.

Equipment and technical data

- Stabilised
- Shortcircuit proof
- Output voltage: 1...12 V DC, 6 V / 12 V AC
- Rated current: DC 0...2 A / AC 5 A
- Ripple: max 1 mV
- Resistance: 1 mΩ
- Mains voltage: 230 V
- Housing dimensions: 194 x 140 x 130 mm

13505-93

P4090260 Measurement of the respiratory rate (with Cobra4)



Respiratory rate after strenuous exercise.

Principle

The respiratory rate increases with physical exertion. The amount of increase depends on different factors such as lung volume, age, sex and training condition. In this experiment the breathing frequency before and after physical exertion is measured and compared.

Tasks

The respiratory frequencies before and after bodily exertion are to be measured and compared.

What you can learn about

- Respiratory frequency
- Chest pressure measurement
- Breathing in resting position
- In slight and strong exertion
- Eupnea
- Diaphragmatic and thoracic respiration

Main articles

Software Cobra4 - multi-user licence	14550-61	1
Cobra4 Sensor-Unit Thermodynamics, pressure abs. 2 bar and 2 temperature NiCr-Ni	12638-00	1
Cobra4 USB-Link	12610-00	1
Connector, t-shaped, metal	05950-00	1
Parafilm -m-, w.100mm, l.38m, 1roll	32986-00	1
Rubber tubing,vacuum, i.d.6mm	39286-00	1
Hose clamp for 10-17 mm diameter	40998-00	1

Human lungs, working model



Function and Applications

Mechanical model for the demonstration of how the human lung functions work.

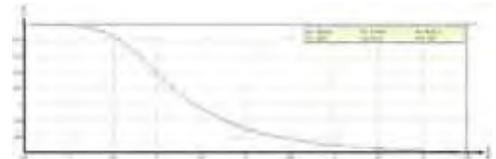
Benefits

- The model shows the expansion of the lungs (rubber balloons) when the breast area (polystyrene jar) is expanded by sinking the diaphragm (rubber cloth).
- Air flows into the lungs through the windpipe and bronchi (glass Y-tube).

66107-88

How much air can our lungs contain? (with Cobra4)

P8001060



The TV measurement display.

Principle

Lungs are organs which enable carbon dioxide (CO₂) to be exhaled and oxygen (O₂) to be absorbed. Contraction of the diaphragm connected to the lungs causes them to stretch so that air is drawn into them from the surroundings. When the diaphragm subsequently relaxes, the lungs return to their original position and air is passively breathed out.

In the following experiment, the lung volume, which is the volume of air which the lungs can take in, is to be determined. A spirometer is used for this measurement. Spirometers are frequently used by physicians to determine irregularities in the functioning of lungs.

Tasks

1. Determine your tidal volume (TV)
2. Determine your expiratory reserve volume (ERV)
3. Determine your inspiratory reserve volume (IRV)

What you can learn about

- Lung; Spirometer; Tidal volume
- Expiratory reserve volume; Inspiratory reserve volume

Main articles

Software Cobra4 - multi-user licence	14550-61	1
Cobra4 Wireless-Link	12601-00	1
Cobra4 Sensor-Unit Spirometry, Pulmonary volume and wind speed	12675-00	1
Cobra4 Wireless Manager	12600-00	1
Disposable turbine with cardboard-mouthpiece, set of 10 (for Cobra4 Sensor-Unit Spirometry)	12675-10	5

Related Experiments

Direct determination of lung volume from a spirogram

P8001160

Does the lung volume depend on how tall you are?

P8001260

Cobra4 Sensor-Unit Spirometry, Pulmonary volume and wind speed

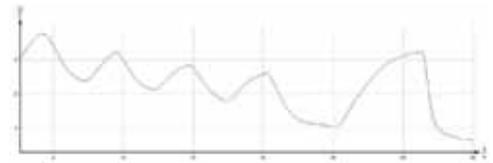


Function and Application

The Cobra4 Sensor Unit Spirometry is used for the measurement of the breath-dependent pulmonary volume. A measurement of wind speed is also possible.

12675-00

P8001360 Diagnosis of lung disease (FEV) (with Cobra4)



Display of recorded data for determining the FEV in one second.

Principle

The forced expiratory volume (FEV) in one second is used in the diagnosis of lung illnesses. For the measurement of this here, the student carrying out the test breathes normally a few times, presses out all the air he or she can, takes a deep breath and holds it for a moment before (at the beginning of measurement) force breathing out as much air as he or she can right from the start of measurement.

Further to this, the vital capacity (as inspiratory VC = IVC) is again to be determined here as it is required for the FEV1 and IVC quotient which is called the Tiffeneau value:

$$\text{Tiffeneau value} = \text{FEV1} / \text{IVC} [\%] \quad (1)$$

With healthy young people, this quotient is 75%. In the case of a so-called obstructive respiratory illness, such as bronchial asthma, the value is far below 75%, as the forced expiratory volume per second is greatly reduced. As this FEV value, just as the vital capacity, depends on the age of the person, among others, older people only reach a value of about 70%.

In contrast to the obstructive illnesses, there are also so-called restrictive respiratory illnesses which cannot be determined using this method.

Tasks

1. Determine the inspiratory vital capacity (IVC) in litres.
2. Determine the one-second forced expiratory volume in one second (FEV1) in litres.

What you can learn about

- Lung illness; Forced expiratory volume (FEV)
- Vital capacity; Tiffeneau value
- Obstructive respiratory illness; Restrictive respiratory illnesses

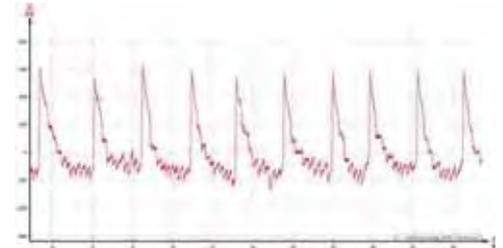
Main articles

Software Cobra4 - multi-user licence	14550-61	1
Cobra4 Wireless-Link	12601-00	1
Cobra4 Sensor-Unit Spirometry, Pulmonary volume and wind speed	12675-00	1
Cobra4 Wireless Manager	12600-00	1



Measuring reading skills (with Cobra4)

P1522260



Typical measurement result of a trained reader while reading an easy text.

Principle

With this experiment, you can determine your own personal reading speed. One's reading speed can be trained and is an important prerequisite for the proper handling of all kinds of texts. You can precisely study the movement of your eyes during the measurement.

Tasks

Explore your reading behaviour reading easy and difficult texts.

What you can learn about

- Reading speed
- Movement of eyes
- Typoglycemia

Main articles

Software Cobra4 - multi-user licence	14550-61	1
Cobra4 Sensor-Unit Electrophysiology: ECG, EMG, EOG	12673-00	1
Cobra4 Wireless-Link	12601-00	1
Cobra4 Wireless Manager	12600-00	1
Shielded leads for electrophysiology, color-coded, 3/pkg	12673-01	1
Electrodes for ECG Sensor, 100 pcs.	12559-01	1

Cobra4 Sensor-Unit Electrophysiology: ECG, EMG, EOG



Function and Applications

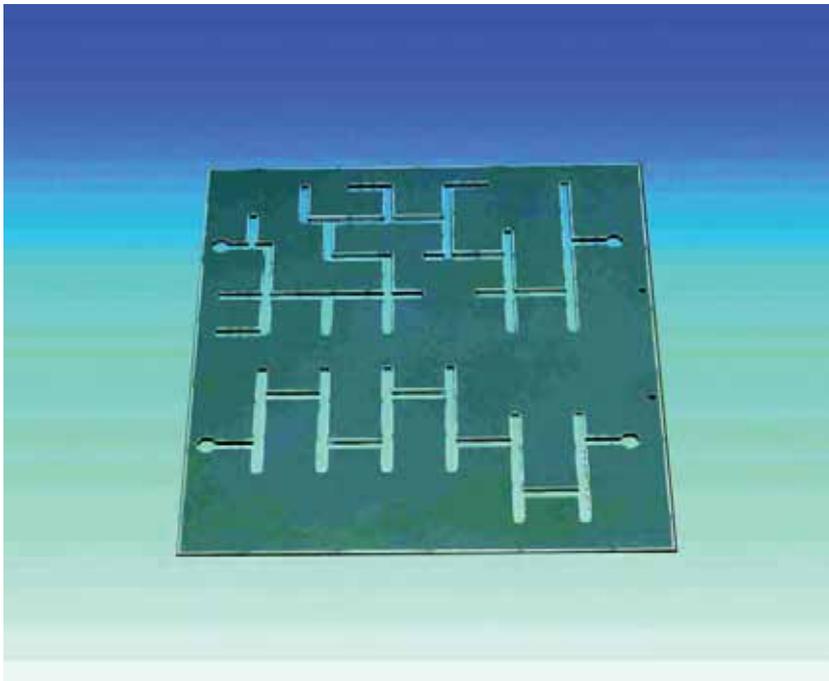
To perform electrophysiological, noninvasive measurements of heart, eye, and muscle activities using the Cobra4 Wireless-Link or the Cobra4 USB-Link.

Benefits

- Multipurpose-sensor: Measure ECG, EMG or EOG.
- self-explanatory pictogram on the sensor yields intuitiv handling of the device.

12673-00

P4080300 Learning performance of humans



Maze.

Principle

The blindfolded test subject has to find the way to the finish with a felt-tip pen in the slits of a finger labyrinth. Success and error are checked by placing a sheet of paper underneath. If a person has to find his way through a labyrinth, he will first of all attempt to obtain an overall view of the labyrinth. If, however, an overview of the labyrinth is prohibited, the test subject is obliged to find his way by trial and error. In the first attempt incorrect paths are frequently selected and the time taken to cross is relatively long. In subsequent practice crossings the number of errors as well as the time required are reduced steadily, until the values settle at a particular level.

Tasks

The learning curves for two different test objectives are drawn: to cross the maze with the least number of errors and as quickly as possible.

What you can learn about

- Finger labyrinth
- Learning behaviour
- Learning curve
- Short term memory
- Medium term memory

Main articles

Stop watch, interruption type	03076-01	1
Finger labyrinth	65990-00	1

Neuro-anatomic brain, 8 parts, model



Function and Applications

Median section, both parts can be dismantled. Color coding of the functional areas of the brain. Median cut, this model shows the right half of the different colored representations of the cerebral cortex. The left half shows, also using different colors following areas: Pre- and post-central region, Broca and Wernicke areas, Heschl'sche Swirl, cranial nerves, ventricles. Both halves of the brain can be divided into: frontal with parietal lobes, temporal with occipital lobes, half of the brain stem, half of the cerebellum.

Equipment and technical data

- on a stand
- numbered parts with information sheet
- dimensions: 14x17x20 cm

87030-00



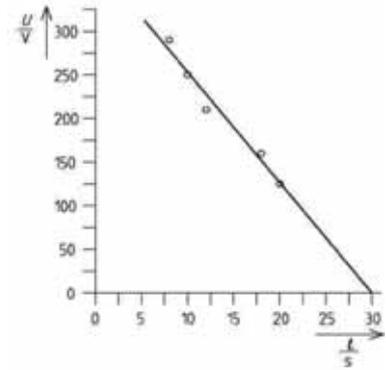
The Nervous System

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3 The Nervous System

3.1 Basics - Potentials and Transport

P3040601 Electrokinetic potential



Dependence of the time required to produce a pressure alternation of 0.1 hPa of the applied cell voltage

Principle

An electrical potential (zeta potential) is formed at a solid-liquid interface, and is the cause of electrokinetic phenomena. On applying an electrical field to a system composed of a fine-grained solid and a liquid, a mechanical movement of the phases is generated. This phenomenon is termed electro-osmosis. The liquid movement can be detected with the aid of a precision manometer.

Tasks

Determine the time required for a pressure change of 0.1 hPa in the U-tube as a function of the applied cell voltage.

What you can learn about

- Electrochemical double layer
- Helmholtz (Smoluchowski) equation
- Electro-osmosis
- Phase boundary

Main articles

Set of Precision Balance Sartorius CPA 623S and measure software, 230 V	49224-88	1
Power supply, 0...600 VDC	13672-93	1
Precision manometer	03091-00	1
Tripod base PHYWE	02002-55	1
U tube, 2 side tubes, GL25/8	36959-15	1
Gasket for GL25, 8mm hole, 10 pcs	41242-03	1
Platin.electrode in prot. tube, 8mm	45206-00	2

Power supply, 0...600 VDC



Function and Applications

Power supply with 5 output voltages especially designed for experiments with tubes, fine beams and conducting the Frank-Hertz experiment.

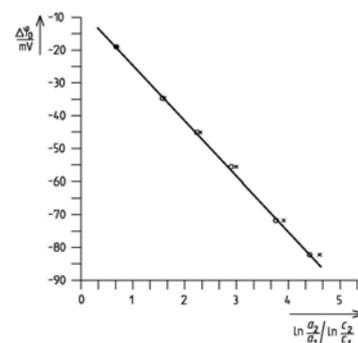
Benefits

- Electronically stabilised DC voltages, short-circuit protected, galvanically isolated from one another so that they can be possible to connected in series, featuring LED current-limiting indicator and protection against polarity reversal
- AC voltage with automatic circuit breaker
- All outputs are floating and isolated from the mains and use 4-mm safety sockets.

13672-93

Determination of diffusion potentials

P3061101



Diffusion potential $\Delta\phi_D$ for HCl as a function of $\ln a_2/a_1$ (0) and $\ln c_2/c_1$ (x) (for cellophane).

Principle

An electrochemical potential establishes itself at the interface between two solutions of different ion concentrations. The magnitude of this is determined by the concentration ratio and the transference numbers of the ions involved. This potential difference can be measured as a function of the concentration at semi-permeable and ion-selective membranes.

Tasks

1. Measure the diffusion potential as a function of the concentration gradient at a cellophane membrane and at a cation-selective membrane.
2. Determine the transference numbers of the ions in HCl, NaCl and KCl.

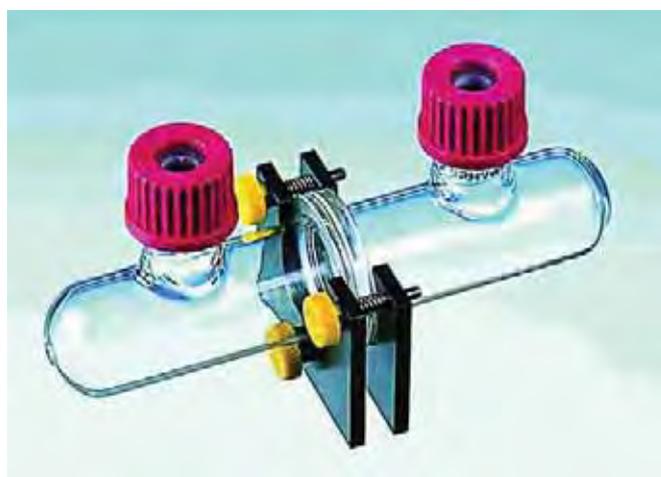
What you can learn about

- Concentration cells with transport; Transference numbers
- Semi-permeable membrane; Selectively permeable membrane
- Nernst equation

Main articles

Set of Precision Balance Sartorius CPA 623S and measure software, 230 V	49224-88	1
Osmosis and electrochemistry chamber	35821-00	1
Digital thermometer, NiCr-Ni, -50...+1300°C	07050-00	1
Magnetic stirrer Mini / MST	47334-93	1
Digital multimeter 2010	07128-00	1
Gasket for GL25, 12mm hole, 10pcs	41243-03	1
Retort stand, h 750 mm	37694-00	1
Reference electrode, AgCl	18475-00	2
Immersion probe NiCr-Ni, steel, -50...400°C	13615-03	1
Membrane, permeable for cations, 5pcs	31504-02	1

Osmosis and electrochemistry chamber



Function and Applications

To the demonstration and observation of osmotic processes. The chamber can be built up and cleaned without problems. Between two sealing rings arbitrary semipermeable membranes can be fixed.

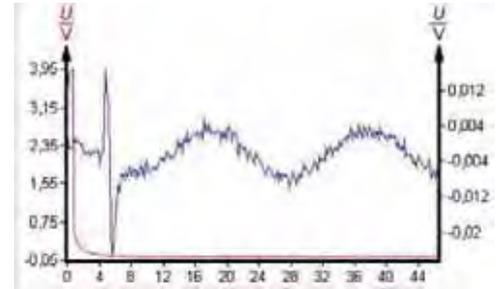
A measurable rise is achieved by the big boundary surface of differently concentrated solutions very quickly in the capillary tube. For the readout of the altitude a scale can be put on the capillary tube.

35821-00

3 The Nervous System

3.1 Basics - Potentials and Transport

P4010462 Model experiment illustrating the development of resting potential (with Cobra4)



Diffusion rates.

Principle and tasks

The potential difference between two electrolyte concentrations separated by a membrane (cellophane or cation permeable) is detected by two silver chloride electrodes. The measured and calculated values are compared.

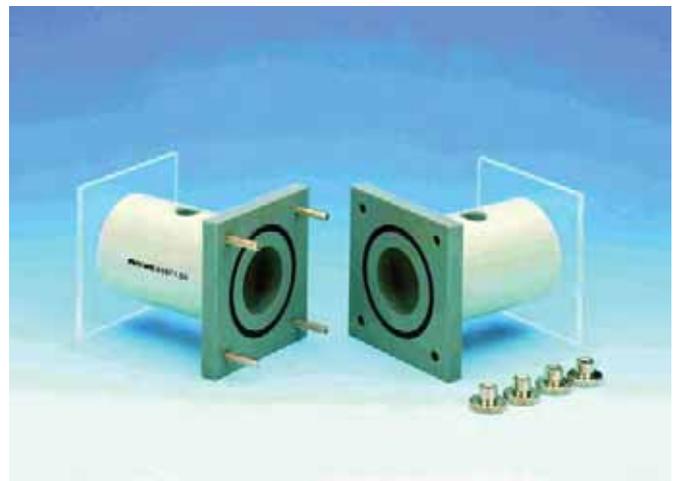
What we can learn about

- Selective ion permeability of membranes
- Resting potential
- Diffusion potential
- Asymmetry potential
- Silver chloride electrodes
- Ion pump

Main articles

Cobra4 Mobile-Link set, incl. rechargeable batteries, SD memory card, USB cable and software "measure"	12620-55	1
Cobra4 Sensor-Unit Chemistry, pH and 2 x Temperature NiCr-Ni	12630-00	1
Ussing chamber	65977-00	1
Reference electrode, AgCl	18475-00	2
Immersion probe NiCr-Ni, steel, -50...400°C	13615-03	1
Potassium chloride 250 g	30098-25	1
Sodium chloride 250 g	30155-25	1

Ussing chamber



Function and Applications

Ussing chamber, two polystyrene tubes with acrylic glass windows and flanges which can be screwed together.

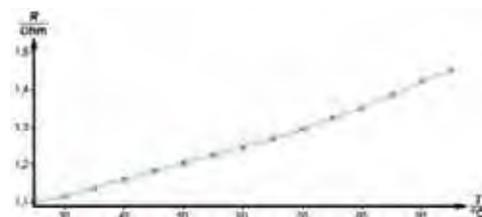
Equipment and technical data

- Each container with a bore for electrodes
- Vascular content 120ml
- Measuring surface approx. 7 cm²

65977-00

Charge transport in solids

P3060111



Dependence of resistance versus temperature (iron wire).

Principle

Measuring the temperature dependence of the resistivity of solids provides information on the mechanism of conduction and charge transport in solids.

Tasks

Determine the temperature coefficient of iron wire, copper wire and constantan wire in the range of room temperature to 95°C.

What you can learn about

- Electron conductivity
- Ion conductivity

Main articles

Power supply, universal	13500-93	1
Cobra3 BASIC-UNIT, USB	12150-50	1
Magnetic stirrer MR Hei-Standard	35750-93	1
Cobra3 current probe 6A	12126-00	1
Digital thermometer, NiCr-Ni, -50...+1300°C	07050-00	1
Immers. probe NiCr-Ni, teflon, 200°C	13615-05	1
Software Cobra3 Universal recorder	14504-61	1

Related Experiment

Ion migration velocity

P3060301

Cobra4 Experiments - available 2013

Conductivity of strong and weak electrolytes (with Cobra4)

P3060660

Power supply, universal



Function and Applications

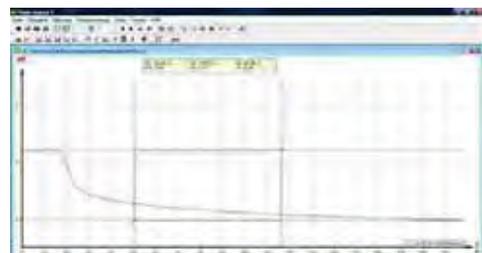
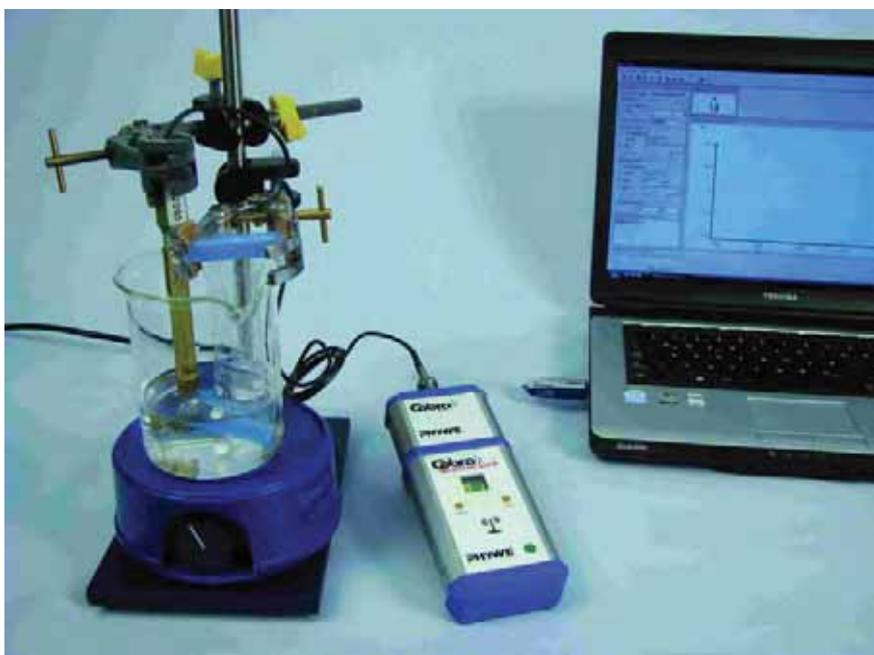
Versatile heavy duty power supply which can also be used as a constant current supply in schools, laboratories or workshops.

13500-93

3 The Nervous System

3.1 Basics - Potentials and Transport

P4120260 The ionic permeability of the cell membrane (with Cobra4)



pH-time-curve showing the release of H⁺ ions.

Principle

The cell membrane regulates the transport of nutrients and water into the cell, and of waste products and water out of the cell. This can take place passively, e.g. on the basis of osmotic processes (differences in concentration), as well as actively.

Tasks

In this experiment, the selective permeability of an artificial cell membrane (dialysis tube) for H⁺ and OH⁻ ions is to be examined.

What you can learn about

- Ionic permeability
- Artificial cell membrane
- Dialysis tube
- H⁺ ions
- OH⁻ ions
- Osmotic processes

Main articles

Software Cobra4 - multi-user licence	14550-61	1
Cobra4 USB-Link	12610-00	1
Cobra4 Sensor-Unit pH, BNC connector	12631-00	1
Magnetic stirrer Mini / MST	47334-93	1
pH-electrode, plastic body, gel, BNC	46265-15	1
Retort stand, h 750 mm	37694-00	1
Caustic soda sol., 1.0M 1000 ml	48329-70	1

Cobra4 Sensor-Unit pH, BNC connector



Function and Applications

The Cobra4 Sensor-Unit pH, BNC connection is a measuring recorder for pH measurements, which is controlled by micro-controller.

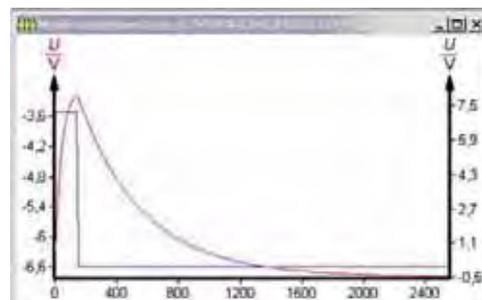
Benefits

- It can be fitted with a pH probe, in order to measure pH values.
- Values of the calibration are saved in the sensor - no need for new calibration after changing the basic unit.
- The sensor is not restricted to the measurement of pH values: Connect the redox electrode 46267-10 to measure redox potentials.
- The unit can be connected to the Cobra4 Wireless-Link, the Cobra4 Mobile-Link or the Cobra4 USB-Link using a secure and reliable plug-in / lockable connection.

12631-00

Neurosimulator: membrane time constant and low-pass filtering (with Cobra3)

P4010511



Result of a single stimulation.

Principle

To show the membrane time constant the neurosimulator is excited by a rectangular pulse from a synapse. The intracellular potential only increases slowly, and then falls off even slower when the stimulation stops. As a result of this behaviour, rapid and brief stimulating signals can only be weakly transmitted (low-pass characteristic of the membrane). In the second part of the experiment, low-pass filtering is investigated. When short rectangular impulses act at relatively large intervals, the intracellular potential can follow the stimulating pulse frequency. The low-pass characteristic of the membrane allows the conversion of the low frequencies to a response.

Tasks

To use a nerve function model to work on the following themes:

- The time constant of the nerve membrane and intracellular potential
- The low-pass characteristic of the nerve membrane

What you can learn about

- Time constant of nerve membrane
- Intracellular potential
- Low-pass characteristic

Main articles

Neuro-simulator	65963-00	1
Cobra3 BASIC-UNIT, USB	12150-50	1
Neuro-simulator, power supply	65963-93	1
Power supply 12V / 2A	12151-99	1
Software Cobra3 Universal recorder	14504-61	1

Cobra4 Experiment - available 2013

Neurosimulator: membrane time constant and low-pass filtering (with Cobra4)

P4010560

Neurosimulator, power supply



Function and Applications

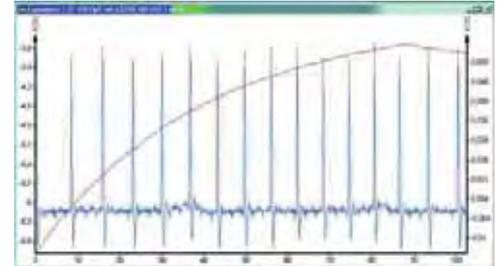
The operating unit comprises the power supply of up to four neuron units, three touch simulators with a variable stimulating intensity and an opticsensor.

Benefits

- The three touch simulators comprise a key button and a turning knob which serves for adjusting the intensity of stimulation (or the height of the provided signal).
- The signal is supplied as long as the stimulation key remains pressed.
- The light sensitive photo sensor allows the simulation of a simple eye showing light dark signal.

65963-93

P4010611 Neurosimulator: mode of operation of excitatory synapses (with Cobra3)



Result of a strong stimulation.

Principle and tasks

To use a nerve function model to work on the following themes:

- The origin of action potentials
- The transformation of stimulation intensity to action potential frequency

What you can learn about

- Action potentials; Intracellular potential
- Excitatory postsynaptic potential (EPSP)
- Nodes of Ranvier; Minimum stimulus intensity
- Frequency modulation

Main articles

Neurosimulator	65963-00	1
Cobra3 BASIC-UNIT, USB	12150-50	1
Neurosimulator, power supply	65963-93	1
Power supply 12V / 2A	12151-99	1
Software Cobra3 Universal recorder	14504-61	1

Cobra4 Experiment - available 2013

Neurosimulator: mode of operation of excitatory synapses (with Cobra4)

P4010660

Neuro-simulator



Function and Applications

The neuron unit Neurosimulator simulates a generalised nerve cell with an apical dendrite and its synaptic contacts, a cell body (soma) and a nerve fibre (axon) with myelin sheathes and a Ranvier's ring.

Benefits

- The dendrite comprises exciting, inhibiting, presynaptic and Hebbian synapses which are marked by the corresponding colours of the sockets
- the connection between the (efferent) axon of a neuron unit which leads away or the stimulus output socket of the operating unit and a synapse is established by means of a white cable which is inserted into the desired synapse socket
- the yellow sockets serve for the derivation of the state of excitement of the simulated neuron
- they can be connected to suitable measuring instruments (e.g. oscilloscope) or a computer interface

65963-00

Neurobiology: nerve cell interactions (with Cobra3)

P4010811



Motoneuron signals with recurrent inhibition by Renshaw cell

Principle

A nerve function model is used to study nerve cell interactions with other nerve cells or with motoric and sensoric cells including the Renshaw inhibition, lateral inhibition, contrast improvement and neuronal principles of classic conditioning such as conditioned reflex.

Tasks

Study the following aspects of nerve cell interactions:

- Motoneuron signals with recurrent inhibition by Renshaw cell
- Motoneuron signals without recurrent inhibition
- Functional characteristics of Renshaw inhibition
- Lateral inhibition
- Contrast improvement
- Conditioned reflex
- Reversed stimulus succession does not bring about a conditioned reflex

What you can learn about

- Lateral inhibition; Contrast improve
- Nerv cell interaction; Conditioned reflex
- Renshaw inhibition; Motoneuron

Main articles

Neurobiology Lab, 230 V	65963-11	1
Additional nerve cell	65963-10	1

Related Experiment

Neurobiology: neural networks

P4010911

Cobra4 Experiments - available 2013

Neurobiology: nerve cell interactions (with Cobra4)

P4010860

Neurobiology: neural networks (with Cobra4)

P4010960

Laboratory Experiments Biology

Description

Instructions for more than 54 experiments covering various areas of biology.

Topics

- Nervous system
- Heart and circulation
- Musculature; Hearing
- Balance
- Sensing temperature
- Sight; Behaviour
- Respiration
- Ecology and the environment
- Plant physiology
- Biochemistry

Format

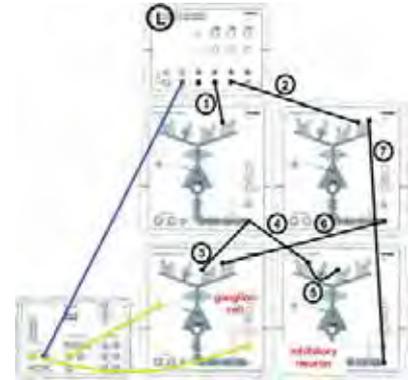
- DIN A4 handbook, spiral binding, b/w, 190 pages

16506-02

3 The Nervous System

3.2 Nerve Cell - Functions, Interactions and Networks

P4011011 Neurobiology: complex neural networks (with Cobra3)



Experimental set-up to show direction selectivity by unilateral inhibition.

Principle

With this experiment setup 30 experiments can be performed covering nerve cells, nerve cell interactions and neural networks. Main topics:

- **Direction selectivity by unilateral inhibition:** Many nerve cells in sensory systems are direction-selective. For example, certain ganglion cells in the retina respond only when a light stimulus moves in a certain direction but not, however, by movements in the reverse direction. Similar behavior is also known for the sense of touch. This neuronal circuit can be simulated using a circuit with unilateral inhibition between two stimulus channels which are activated successively.
- **Self-calibration of paired sensory channels:** Embryonal formation of axis-symmetrical species is not perfect, resulting in slight irregularities of the symmetry. Irregularities of sensory epithelia, e.g. in the equilibrium organ, can be compensated by the nerve system: Hebbian principle offers the possibility to adjust the output signals so that they are symmetrical when the sensory organs are asymmetrical.

Tasks

1. Use the nerve function model to study direction selectivity by unilateral inhibition.
2. Use the nerve function model to study self-calibration of paired sensory channels.

What you can learn about

- Unilateral inhibition
- Self-calibration of paired sensory channels
- Nerve cell interaction
- Neural network
- Ganglion cell
- Axon
- Interneuron

Main articles

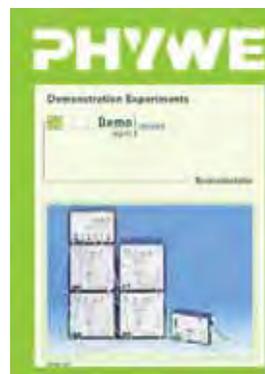
Neurobiology Lab, 230 V	65963-11	1
Additional nerve cell	65963-10	3

Cobra4 Experiment - available 2013

Neurobiology: complex neural networks (with Cobra4)

P4011060

Demonstration Experiments Neurosimulator

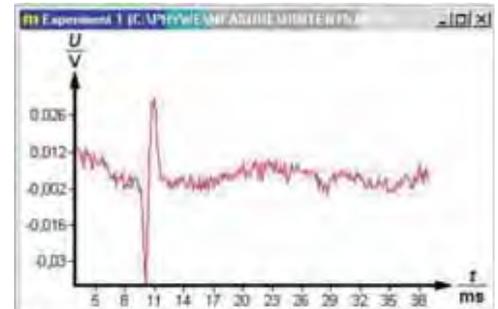


Experiment Descriptions for up to 4 Neurosimulators. Incl. photos for quick and easy set-up of the experiments.

01191-02

Recording of nerve and muscle potentials by mechanical stimulation at the rear end of an earthworm (with Cobra3)

P4010111



Result with weak stimulation.

Principle

Earthworms have a median giant nerve fibre, which reacts to stimulation at the front end, and two lateral giant fibres, which can be stimulated at the rear end. The experiment covers the following topics: the course of a biphasic action potential over time, estimation of the conduction velocity and coding of the stimulant intensity as frequency modulation.

Tasks

1. Stimulate the earth worm with weak, moderate and strong stimulation.
2. Observe the course of the biphasic action potential over time.
3. Estimate the conduction velocity.

What you can learn about

- Nerve and muscle potentials
- Mechanical stimulation
- Biphasic action potential
- Frequency modulation
- Median and lateral giant nerve fibres
- Conduction velocity

Main articles

Cobra3 BASIC-UNIT, USB	12150-50	1
Biological amplifier	65961-93	1
Earthworm experiment chamber	65981-20	1
Stimulus bristle, triggering	65981-21	1
Power supply 12V / 2A	12151-99	1
Software Cobra3 Universal recorder	14504-61	1
Adapter, BNC-plug/socket 4 mm	07542-26	1

Related Experiments

Recording of nerve and muscle potentials by mechanical stimulation at the front end of an earthworm (with Cobra3)

P4010211

Recording of nerve potentials after the electrical stimulation of an anaesthetised earthworm (with Cobra3)

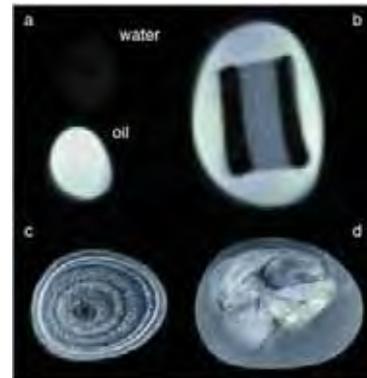
P4010311

Cobra4 Experiment - available 2013

Recording of nerve and muscle potentials by mechanical stimulation at the rear end of an earthworm (with Cobra4)

P4010160

P5942400 Magnetic Resonance Imaging (MRI)



MR imaging examples. a: water and oil, b: phantom sample, c: branch, d: honey bee head.

Principle

The basic principles of 2D MR imaging are demonstrated with two methods relying on two different gradient techniques. Experiments are executed with a MRT training device giving the opportunity to investigate some small probes in the sample chamber. Device control is done with the provided software. Investigations comprise the generation of a two-dimensional cross-section image via the spin echo technique, i.e. a spin echo signal is investigated while simultaneously superimposed with a magnetic field gradient, and the generation of a two-dimensional cross-section image via the gradient echo technique, i.e. a particular gradient echo signal is investigated. The latter technique is closely linked to the FLASH (Fast Low Angle Shot) which is an ultrafast technique in MR imaging.

Tasks

1. Using the frequency and phase gradient techniques to generate a spin echo signal which can be used for 2D image reconstruction (Spin Echo 2D).
2. Using the frequency and phase gradient techniques to generate a gradient echo signal which can be used for 2D image reconstruction (Flash 2D).

What you can learn about

- Nuclear spins, Precession of nuclear spins
- Resonance condition, MR frequency, MR flip angle
- FID signal (Free Induction Decay), Magnetic gradient fields
- Spatial encoding (frequency coding, phase coding)
- Spin echo, gradient echo, Fast-Fourier-Transformation (FFT)
- T1/T2 relaxation times, De-/Rephasing

Main articles

Compact MRT 09500-99 1

Related Experiments

Basic principles in Nuclear Magnetic Resonance (NMR)

P5942100

Relaxation times in Nuclear Magnetic Resonance

P5942200

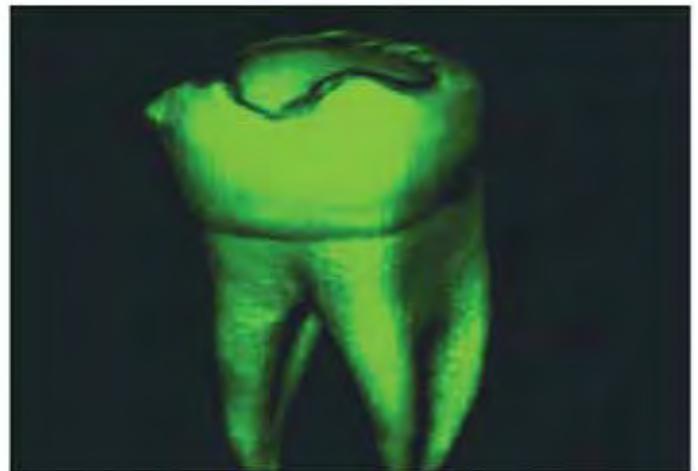
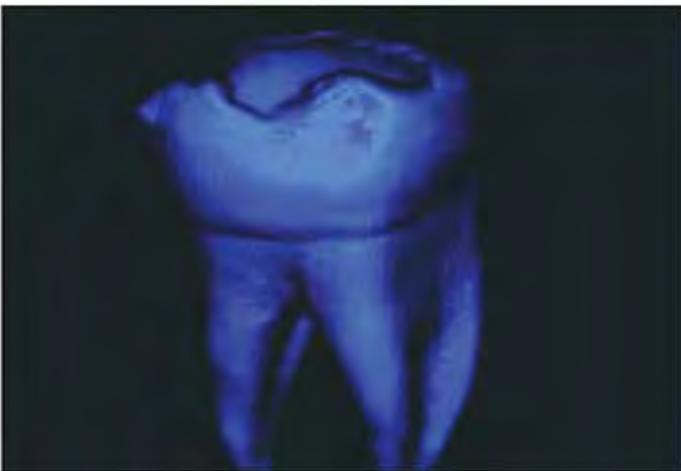
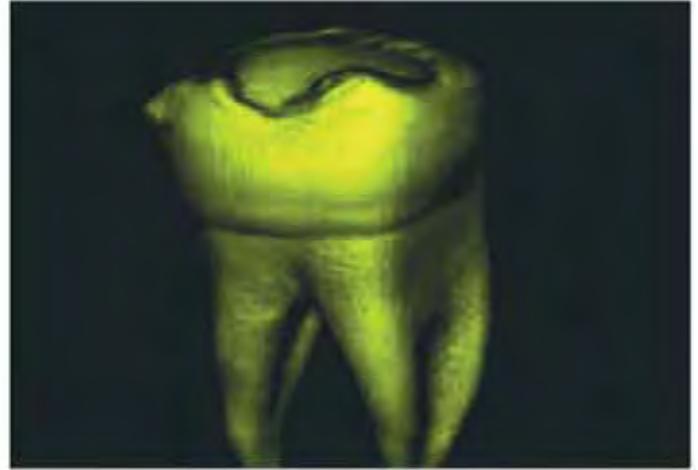
Spatial encoding in Nuclear Magnetic Resonance

P5942300

Training recommended **Service** PHYWE

For this experiment we recommend a seminar on equipment technology, handling and information of equipment-specific characteristics on site.

03333-02



Radiology and Ultrasonic Diagnostics

4.1	X-ray Computed Tomography (CT) and Imaging	60
4.2	Magnetic Resonance Imaging (MRI)	71
4.3	Ultrasonic Imaging	74
4.4	Nano Imaging	80
4.5	Literature	83

XRE 4.0 expert set – Details at a glance

Experience the perfect synthesis of innovative technology, highest level of safety, well-proven PHYWE quality and modern design. Extensive performance characteristics and ideas make working with the PHYWE XR 4.0 a special experience.

We have presented some device highlights for you here.

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

3View - Insight provides a transparent view

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



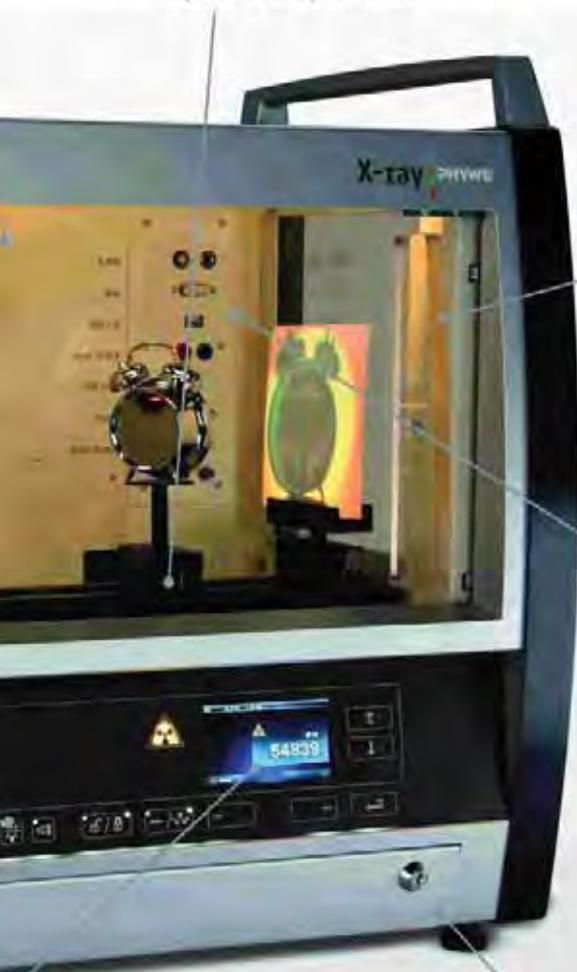
XXL Chamber

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



Optical bench with riders

- Radiography experiments
- Simple, precise positioning of optical components



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
- Patent pending

Goniometer (not pictured)

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



Multilink

- Connection field internal and external
- USB 2.0, N₂, BNC, XRED, Aux, etc.
- No annoying „cable-laying“
- In addition, extra-large cable conduit

High-resolution TFT backlit display

- Diagonal 4,3“
- 480 x 272 Pixel
- 16 Bit, 65.536 colors
- With LED lighting
- Optimal, dynamic representation of all important device parameters and measured values



Safekeeping drawer

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

4 Radiology and Ultrasonic Diagnostics

4.1 X-ray Computed Tomography (CT) and Imaging

XR 4.0 expert unit – Sets for all applications

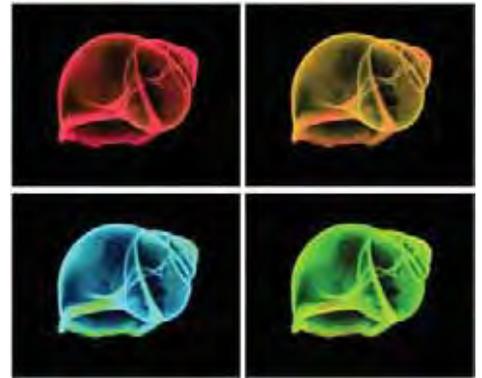
Basic set	Core components (incl. further accessories)	Areas of application	Application examples
XR 4.0 expert set Art. No. 09110-88 (Basic set)	<ul style="list-style-type: none"> XR 4.0 expert unit (X-ray device); Tungsten tube (W); XR measure 4.0 X-ray software; optical bank; TESS expert manual fluorescent screen USB cable, mains cable + adaptor 		<ul style="list-style-type: none"> Basics & applications of X-radiation Radiographic experiments Radiology

Extend the basic set with the respective extension set according to area of application

Extension sets (optional)	Core components (incl. further accessories)	Areas of application	Application examples
XRP 4.0 solid-state physics Art. No. 09120-88	<ul style="list-style-type: none"> Goniometer, GM counter tube, LiF / KBr single crystal absorption set 		<ul style="list-style-type: none"> Diffractionmetry X-ray spectroscopy Bragg-reflection / Bremsstrahlung Characteristic lines
XRC 4.0 characterization Art. No. 09130-88	<ul style="list-style-type: none"> 3 X-ray tubes (Cu, Fe, Mo) Goniometer, GM counter tube, LiF / KBr single crystal 		<ul style="list-style-type: none"> Radiation spectrums of the anode Moseley law Rydberg constant Duane-Hunt law
XRS 4.0 structure analysis Art. No. 09140-88	<ul style="list-style-type: none"> Goniometer, GM counter tube, LiF / KBr / NaCl single crystal Crystal holder powder samples 		<ul style="list-style-type: none"> Structure investigations Laue patterns Debye-Scherrer recordings X-ray analysis
XRM 4.0 material analysis Art. No. 09160-88	<ul style="list-style-type: none"> Goniometer X-ray energy detector Multi-channel analyzer Sample sets 		<ul style="list-style-type: none"> X-ray fluorescence spectroscopy Non-destructive testing (NDT) Compton Effect Energy-dispersive experiments
XRI 4.0 radio photography Art.-Nr. 09150-88	<ul style="list-style-type: none"> Camera Radiographic object Model loader Implant model 		<ul style="list-style-type: none"> Basics for the X-ray image provision Radiography Radiology Non-destructive testing (NDT)
XRD 4.0 dosimetry and radiation damage Art. No. 09170-88	<ul style="list-style-type: none"> Parallel-plate capacitor Power supply unit 600 V DC current amplifier Camera 		<ul style="list-style-type: none"> Dosimetry Degradation Damage Ionization of air
XRCT 4.0 computer tomography Art. No. 09180-88	<ul style="list-style-type: none"> Direct, digital X-ray image sensor Rotation unit, vertical rotation measure Tomography software package 		<ul style="list-style-type: none"> 3-dimensional reconstruction Sectional drawings in respective position Direct, digital image provision
XRW 4.0 wireless demonstration Art. No. 09115-88	<ul style="list-style-type: none"> Digital display panel Cobra4 Display-Connect Transmitter and receiver, etc. 		<ul style="list-style-type: none"> Demonstration experiments (operation without computers) Placard-style representation of the measured values and parameters

Computed tomography

P2550100



CT of a Snail shell.

Principle

The CT principle is demonstrated with the aid of simple objects. In the case of very simple targets, only a few images need to be taken in order to achieve a good result. The more complicated the objects are, the more images are necessary in order to show all the details. In addition, special samples are used to demonstrate how artefacts are generated and what causes beam hardening.

Tasks

1. Record a CT scan of the simple objects. While doing so, vary the number of steps.
2. Record a CT scan of the metal samples and analyse the result in view of beam hardening.

What you can learn about

- Beam hardening; Artefacts; Algorithms

Main articles		
XRE 4.0 X-ray expert set	09110-88	1
XR 4.0 X-ray Direct Digital Image Sensor (XRIS) with USB cable	09057-40	1
XR 4.0 X-ray CT Z-rotation stage (XRstage)	09057-42	1

Best fitting X-ray sets for this experiment:	
XRE 4.0 X-ray expert set	
09110-88	
XRCT 4.0 X-ray Computed Tomography upgrade set	
09180-88	



EduMedia Award for Didactical Software for:



Allan M. Cormack (left)
Sir Godfrey Newbold Hounsfield (right)
1979, Nobel Prize in Medicine

4 Radiology and Ultrasonic Diagnostics

4.1 X-ray Computed Tomography (CT) and Imaging

XRE 4.0 X-ray expert set



Function and Applications

Basic set covering the fundamental principles and areas of applications of X-rays, e.g. fluoroscopy experiments and X-ray photography. It can be extended by upgrade sets for specific applications and topics.

Benefits

- Safety concept complying with the applicable standards and regulations
- S-Lock - PHYWE novel Safety interlock
- Design Patent, Protection of Utility Patent, General Patent pending
- Tube XChange Technology
- Touch Panel
- 3View - Insight provides a transparent view
- High-resolution TFT backlit display
- XXL Chamber
- Optical bank with riders
- Goniometer (optional)
- MultiLINK
- Safekeeping drawer

Equipment and technical data

The set includes the following components:

- XR 4.0 expert unit
- XR 4.0 X-ray plug-in unit with a tungsten X-ray tube
- XR measure 4.0 X software
- TESS expert manual "Experiment with X-radiation"
- USB cable, mains cable with adaptor
- Optical bench with
- Quick-start guide, operating instruction
- Fluorescent screen

Recommended upgrade sets for various applications and topics

- XRW 4.0 X-ray wireless demonstration upgrade set, 09115-88
- XRP 4.0 X-ray solid state upgrade set, 09120-88
- XRC 4.0 X-ray characteristics upgrade set, 09130-88
- XRS 4.0 X-ray structural analysis upgrade set, 09140-88
- XRI 4.0 X-ray imaging upgrade set, 09150-88
- XRM 4.0 X-ray material analysis upgrade set, 09160-88
- XRD 4.0 X-ray dosimetry and radiation damage upgrade set, 09170-88
- XRCT 4.0 X-ray Computer Tomography upgrade set, 09180-88

09110-88

XRCT 4.0 X-ray Computed Tomography upgrade set



Function and Applications

Upgrade set as an extension of the XRE 4.0 expert set (09110-88). Show the fundamental principles of computed tomography (CT) with the aid of a state of the art system whose technology is currently applied in medical and industrial applications. The interfaces of this method towards medicine, materials science and engineering make the "Computed Tomography Set" particularly suitable for laboratory experiments and lectures in physics, medicine, and materials science. The set covers the following experiments and topics:

- X-ray imaging of biological and technical samples
- Non-destructive testing (NDT)
- Digital image processing for the generation of three-dimensional images of an object, Digital images of Laue patterns

Benefits

- Acquisition of the X-ray images by a direct X-ray direct digital image sensor: No extra fluorescent screen is necessary, experimentation under daylight conditions is possible.
- High-performance image sensors for the direct digital X-ray radiography to create superior image quality, and high resolution based on CMOS technology. Even pictures with low contrast like Laue patterns are made in less than 1 min
- Z-axis rotation of the sample to be analysed: Movement of the sample is not influenced by gravitational effects, rigid bodies of flexible size can be analysed on a simple way.
- Acquisition of high resolution CT scan, 360° image stack within 10 minutes (one frame per second, one degree per frame)
- Protection of Utility Patent, registered by "Deutsches Patent- und Markenamt"

Equipment and technical data

The set includes the following components:

- XR 4.0 direct digital image sensor, 09057-41
 - Active area 5 x 5 cm²
 - Resolution 46 µm
 - Image depth 12 bit
 - USB 2.0 interface
- XR 4.0 CT object Z-rotation unit, 09057-41
 - Angle resolution < 1 degree
 - Motorised, USB 2.0 interface
 - Stepper motor with 4200 steps/360°
- Measure XR 4.0 tomography software package, 14421-61
- XR 4.0 CT accessories, 09057-42

09180-88

XR 4.0 X-ray Direct Digital Image Sensor (XRIS) with USB cable



Function and Applications

Digital X-ray camera to perform X-ray imaging (radiography) and X-ray Computer Tomography (CT) experiments. Particularly suitable for experiments in lab courses and lectures in physics, medical education and material sciences.

Benefits

- Direct acquisition of the X-ray images by a direct X-ray direct digital image sensor: Experimentation under daylight conditions
- High-performance CMOS image sensors for the direct digital X-ray radiography to create superior image quality, high resolution, and large active area images based on CMOS technology.

Equipment and technical data

- Active area 5 x 5 cm², Resolution 48 μm, Image depth 12 bit
- USB 2.0 interface
- USB-cable

09057-40

XR 4.0 X-ray CT Z-rotation stage (XRstage)



Function and Applications

Rotating table to position samples e.g. for the CT application.

Benefits

- Z-axis rotation of the sample to be analysed: Movement of the sample is not influenced by gravitational effects, rigid bodies of flexible size can be analysed on a simple way.

Equipment and technical data

- Angle resolution < 1 degree, Motorised
- Plug&measure interface, stepper motor with 4200 steps/360°

09057-42

XR 4.0 Software measure CT



Function and Applications

Software package of the "measure" series for controlling the digital X-ray sensor XRIS and the X-ray unit XR 4.0. The data can be exported in all of the established formats and then evaluated with the aid of professional software. This ensures a smooth transition from training to professional application.

Benefits

Plug & measure:

- The intuitive user concept considerably simplifies the operation of the complex devices and puts the experiment into the focus of attention. Automatic identification of the connected devices of the XR 4.0 series. Working directly without the need for specialist knowledge.

Double Control:

- Simultaneous operation via manual control or via a computer.

Reference experiments:

- The comprehensive collection of reference experiments and projects simplifies the selection of suitable experiments and can be used as a template for own experiment scripts/laboratory handbooks.

Clear structure:

- The software is clearly divided into the 4 basic steps: "Parameters", "CT scan", "Reconstruction", and "3D view". As a result, even beginners can easily familiarise themselves with the topic. Visualisation of the devices: In the first steps, numerous parameters must be set, e.g. the anode current and voltage. In order to facilitate these steps, the corresponding devices are displayed as virtual devices.

CT scan with live reconstruction:

- Sectional images are reconstructed during the scanning process. While at the beginning of the measurement hardly anything can be discerned, the contours become increasingly clear over time.

Reconstruction as an independent step: Reconstruction is the most important process step in computed tomography. Again, numerous parameters play an important role during this step. They can be changed in their own screen and their effect can be observed directly in an example image.

x,y,z-viewer and 3D view

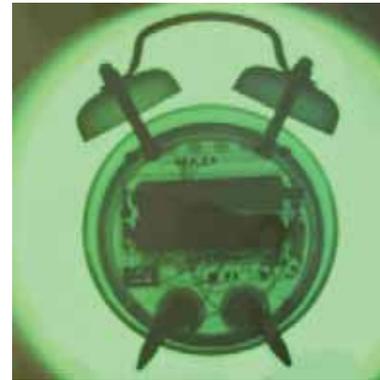
- This area shows the results of the reconstruction process. The data can now be evaluated with professional software that the students will encounter in their future daily work. The data can be exported in all of the established formats.

Recommended System requirements:

PC with at least an Intel Core i7 2600 (3.4GHz) 8MB - 4 Cores, 8GB (2x 4GB) 1600MHz DDR3, 40GB free hard drive space, DVD-drive, 4x USB 2.0, Microsoft Windows 7 64bit or higher. Graphic card: MSI nVidia GeForce N440GT 1GB or better.

14421-61

P2540020 Radiographic examination of objects



Radiography of a digital alarm clock.

Principle

An X-ray tube produces X-rays that cause a fluorescent screen to emit light. Objects that are located between the X-ray source and the fluorescent screen will be irradiated so that their inner structure becomes visible. If one varies the anode current and voltage, the change in intensity can be observed in a qualitative manner on the fluorescent screen.

Tasks

1. X-ray an object and observe the result on the fluorescent screen.
2. Vary the anode current and voltage and observe the result on the fluorescent screen.

What you can learn about

- X-ray tube; Absorption of X-rays, Radiography, Fluorescence

Main articles

XR 4.0 expert unit	09057-99	1
XR 4.0 X-ray plug-in unit W tube	09057-80	1
XR 4.0 X-ray fluorescent screen	09057-26	1

Best fitting X-ray set for this experiment:

XRE 4.0 X-ray expert set

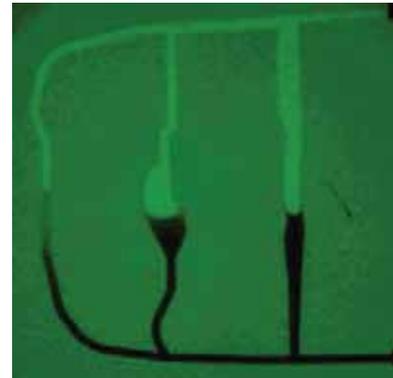
09110-88



Wilhelm Conrad Röntgen
 1901, Nobel Prize in Physics

Contrast medium experiment with a blood vessel model

P2541901



Blood vessel model with the contrast medium half filled.

Principle

When a blood vessel model is irradiated with X-rays, the blood vessels themselves are not visible at first. It is only after the injection of a contrast medium that the blood vessels become visible.

Tasks

1. Inject a 50% potassium iodide solution into the blood vessel model.
2. Observe the fluorescent screen of the X-ray basic unit to follow the course taken by the injected solution in the blood vessel model.

What you can learn about

- X-ray radiation, Bremsstrahlung
- Characteristic radiation, Law of absorption
- Mass absorption coefficient; Contrast medium

Main articles

XR 4.0 expert unit	09057-99	1
XR 4.0 X-ray plug-in unit W tube	09057-80	1
XR 4.0 X-ray fluorescent screen	09057-26	1
XR 4.0 X-ray Blood vess.model f.contrast fluid	09058-06	1

Best fitting X-ray sets for this experiment:

XRE 4.0 X-ray expert set

09110-88

XRI 4.0 X-ray imaging upgrade set

09150-88

XR 4.0 Mobile X-ray Lab



Function and Applications

Teaching and performing experiments with the mobile X-ray lab. The mobile X-ray lab saves valuable time by making the set-up and dismantling of experiments in the classroom or lecture hall redundant. All of the important parts, such as X-ray tubes, goniometer, or multi-channel analyser, can be stored safely in the lockable cabinet. Prepare your experiments unhurriedly ahead of time before pushing them into the room at time of the lecture. Cluttered set-ups and tangled cables are a thing of the past: The most important connectors are located on the desktop. The screen is fixed in place on the desktop in a permanent manner in order to protect it against damage and theft.

09057-48

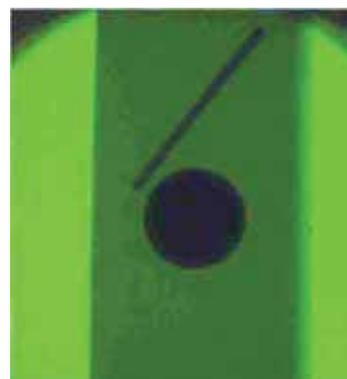
4 Radiology and Ultrasonic Diagnostics

4.1 X-ray Computed Tomography (CT) and Imaging

P2542001 Determination of length and position of an object which can not be seen



NEW



Pictures of the implant model projection in the y,z-plane.

Principle

This experiment provides training in determining the length and position of an object based on an X-ray image. A metal pin that is embedded in a wooden block is used as the model. This experiment is also an excellent preparatory exercise for demonstrating the principle of computed tomography.

Tasks

1. Record a bi-planar radiogram of two perpendicular planes of a metal pin which cannot be seen.
2. Determine the true length of the pin by taking into account the magnification factor which results from the divergence of the X-rays.
3. Determine the spatial position of the pin.

What you can learn about

- X-ray radiation
- Bremsstrahlung
- Characteristic radiation
- Law of absorption
- Mass absorption coefficient
- Stereographic projection

Main articles

XR 4.0 expert unit	09057-99	1
XR 4.0 X-ray plug-in unit W tube	09057-80	1
XR 4.0 X-ray Implant model	09058-07	1

Best fitting X-ray sets for this experiment:

XR 4.0 X-ray expert set

09110-88

XRI 4.0 X-ray imaging upgrade set

09150-88

XR 4.0 expert unit



Function and Applications

School/full-protection device with X-ray tube quick-change technology for fluoroscopy and X-ray imaging, ionisation and dosimetry experiments, Laue and Debye-Scherrer images, X-ray spectroscopy, Bragg reflection, bremspectrum /characteristic lines of various different anode materials, Moseley's law, determination of Planck's constant and Rydberg constant, Duane Hunt's law, material-thickness- and energy-dependent absorption, K and L edges, contrast medium experiments, Compton scattering, and X-ray diffractometry.

09057-99

Qualitative examination of absorption

P2540030



From left to right: aluminium, cardboard, iron (all of them: d=1 mm).

Principle

X-rays penetrate objects that are impenetrable for visible light. The absorption depends on the thickness and type of the material. This dependence is demonstrated in a qualitative manner on a fluorescent screen with the aid of various different absorption specimens.

Tasks

1. Observe the transmission of X-rays as a function of the material thickness.
2. Determine how the atomic number of the elements in a material affects the transmission of X-rays.

What you can learn about

- X-ray tube, absorption of X-rays; atomic number
- fluorescence, Lambert-Beer

Main articles

XR 4.0 expert unit	09057-99	1
XR 4.0 X-ray plug-in unit W tube	09057-80	1
XR 4.0 X-ray fluorescent screen	09057-26	1
XR 4.0 X-ray optical bench	09057-18	1
Slide mount for optical bench, h = 30 mm	08286-01	2

Best fitting X-ray set for this experiment:

XRE 4.0 X-ray expert set

09110-88

XR 4.0 X-ray plug-in unit W tube



Function and Applications

Factory adjusted tungsten tube in sheet steel housing ready for use in connection with XR 4.0 expert unit. Housing with plugs to accept the tubes operating quantities from the basic unit. With handle, mechanical lock and two switching pins, which only operate correspondingly security microswitches of the basic unit when the plug-in module is correctly inserted.

Benefits

Tube XChange Technology:

- Quick-change technology for four different X-ray tubes (W, Cu, Mo, and Fe), adjustment free, complete protection against touching hot parts

Equipment and technical data

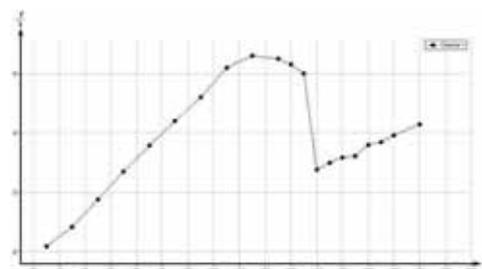
- Anode angle 19°, Max. operation datas 1 mA/35 kV
- Test voltage 50 kV, Mass 4.3 kg
- Dimensions (26.7 x 18.8 x 20.3) cm

09057-80

4 Radiology and Ultrasonic Diagnostics

4.1 X-ray Computed Tomography (CT) and Imaging

P2541101 Absorption of X-rays



Absorption edge of copper; UA = 25 kV; $\lambda_K = 138$ pm.

Principle

The polychromatic X-radiation that is emitted by an X-ray tube is filtered in terms of its energy with the aid of a monocrystal.

The resulting monochromatic radiation is used as the primary radiation source for examining the absorption behaviour of various metal foils of different thicknesses.

Tasks

1. Determine the attenuation of the X-radiation by aluminium and zinc foils of different thicknesses and at two different wavelengths of the primary radiation.
2. Determine the mass absorption coefficient μ/ρ for aluminium, zinc, and tin absorbers of constant thickness as a function of the wavelength of the primary radiation. Prove the validity of $\mu/\rho = f(\lambda^3)$ in a graphical manner.
3. Determine the absorption coefficients μ for copper and nickel as a function of the wavelength of the primary radiation. Determine the energy values of the corresponding K shells based on the graphical representation. Prove the validity of $\mu/\rho = f(\lambda^3)$.

What you can learn about

- Bremsstrahlung; Characteristic radiation
- Bragg scattering; Law of absorption
- Mass absorption coefficient; Absorption edge
- Half value thickness; Photoelectric effect
- Compton scattering; Pair production

Main articles

XR 4.0 expert unit	09057-99	1
XR 4.0 X-ray goniometer	09057-10	1
XR 4.0 X-ray Plug-in Cu tube	09057-50	1
XR 4.0 Software measure X-ray	14414-61	1
Geiger-Mueller Counter tube, type B	09005-00	1

Related Experiment

X-ray dosimetry

P2541801

Best fitting X-ray sets for this experiment:

XRE 4.0 X-ray expert set

09110-88

XR 4.0 X-ray Solid state physics upgrade set

09120-88

XR 4.0 X-ray goniometer



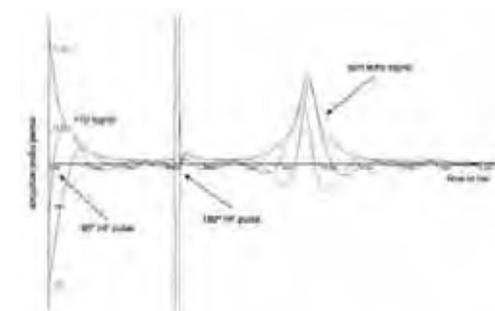
Function and Applications

Goniometer with two independent stepper motors for the precise angular positioning of a sample and detector.

09057-10

Basic principles in Nuclear Magnetic Resonance (NMR)

P5942100



Spin echo signal of an oil sample occurring 10 ms (echo time) after a 90° HF pulse (FID signal is shown). To generate the echo signal a 180° HF pulse has to be switched after half the echo time.

Principle

The basic principles concerning the phenomenon of nuclear magnetic resonance (NMR) are demonstrated. Experiments are executed with a MRT training device giving the opportunity to investigate some small probes in the sample chamber. Device control is done with the provided software. Investigations comprise the tuning of the system frequency to the Larmor frequency, the determination of the flip angle of the magnetization vector, the effects of the substance quantity, the influence of particular magnetic field inhomogeneities, the measurement of a spin echo signal and an averaging procedure to maximize the signal-to-noise ratio. The adjustment of all parameters in these experiments are inevitable to obtain an adequate MR image.

Tasks

1. Tuning of the system frequency to the Larmor frequency.
2. Setting of the HF (High Frequency) pulse duration to determine the flip angle of the magnetization vector.
3. Effects of the substance quantity on the FID signal (Free Induction Decay) amplitude.
4. Minimizing magnetic field inhomogeneities via a superimposed magnetic field (shim).
5. Retrieving a relaxed FID signal via a spin echo flipping nuclear spins by 180°.
6. Improving the signal-to-noise ratio (SNR) of the FID signal.

What you can learn about

- Nuclear spins; Atomic nuclei with a magnetic moment
- Precession of nuclear spins; Magnetization
- Resonance condition; MR frequency; MR flip angle
- FID signal (Free Induction Decay); Spin echo
- Relaxation times (T1: longitudinal magnetization, T2: transverse magnetization)
- Signal-to-noise ratio

Main articles

Compact MRT	09500-99	1
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Related Experiments

Relaxation times in Nuclear Magnetic Resonance

P5942200

Spatial encoding in Nuclear Magnetic Resonance

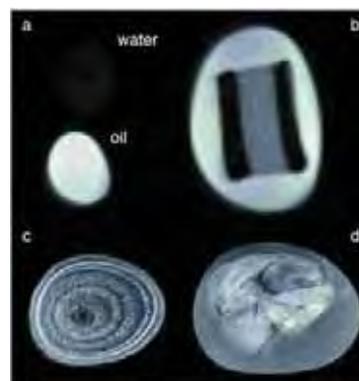
P5942300

Training recommended **Service** | PHYWE

For this experiment we recommend a seminar on equipment technology, handling and information of equipment-specific characteristics on site.

03333-02

P5942400 Magnetic Resonance Imaging (MRI)



MR imaging examples. a: water and oil, b: phantom sample, c: branch, d: honey bee head.

Principle

The basic principles of 2D MR imaging are demonstrated with two methods relying on two different gradient techniques. Experiments are executed with a MRT training device giving the opportunity to investigate some small probes in the sample chamber. Device control is done with the provided software. Investigations comprise the generation of a two-dimensional cross-section image via the spin echo technique, i.e. a spin echo signal is investigated while simultaneously superimposed with a magnetic field gradient, and the generation of a two-dimensional cross-section image via the gradient echo technique, i.e. a particular gradient echo signal is investigated. The latter technique is closely linked to the FLASH (Fast Low Angle Shot) which is an ultrafast technique in MR imaging.

Tasks

1. Using the frequency and phase gradient techniques to generate a spin echo signal which can be used for 2D image reconstruction (Spin Echo 2D).
2. Using the frequency and phase gradient techniques to generate a gradient echo signal which can be used for 2D image reconstruction (Flash 2D).

What you can learn about

- Nuclear spins, Precession of nuclear spins
- Resonance condition, MR frequency, MR flip angle
- FID signal (Free Induction Decay), Magnetic gradient fields
- Spatial encoding (frequency coding, phase coding)
- Spin echo, gradient echo, Fast-Fourier-Transformation (FFT)
- T1/T2 relaxation times, De-/Rephasing

Main articles

Compact MRT 09500-99 1

Training recommended **Service** PHYWE

For this experiment we recommend a seminar on equipment technology, handling and information of equipment-specific characteristics on site.

03333-02



Felix Bloch (left)

Edward M. Purcell (right)

1952, Nobel Prize in Physics

Compact MRT



Function and Applications

The system gives you the unique opportunity of offering training at a real magnetic resonance tomograph (MRT), which is used in almost all fields of science and medicine, directly on site. The training software and the experiment instructions cover all key aspects of the magnetic resonance technology, ranging from the basic principles of nuclear magnetic resonance (NMR) to the complex high-resolution MR imaging (MRI). Thus, students can perform some basic experiments of the MR technology as well as generate, export and analyze numerous high-resolution images in all relevant contrasts. The special option to influence experiments on runtime and to directly visualize the results gives users an unprecedented learning experience. Thereby image artifacts found in clinical MRT can be examined directly in a simple process. The system consists of a "control unit" and a "magnet unit", which differ from other magnetic resonance tomographs only in the size and the fact that they are portable.

Benefits

- Easy to connect and immediately operative (USB 2.0)
- New and numerous education experience
 - training with clinically relevant measuring procedures
 - high resolution MR imaging (2D, 3D)
 - live visualization of data
 - realtime control of experimental parameters
- Practice-oriented training for all fields of science and medicine
 - T1/T2 measurements
 - all MR parameters accessible
 - measure a multitude of samples with a diameter up to one centimeter
 - software perfectly fits the study purposes
 - suitable for a wide range of experiments
- Literature tailored precisely to the experiments (5 TESS expert experimental units: Basic principles in Nuclear Magnetic Resonance (NMR), Relaxation times in Nuclear Magnetic Resonance, Spatial encoding in Nuclear Magnetic Resonance, Magnetic Resonance Imaging (MRI) I, Magnetic Resonance Imaging (MRI) II)
- Possibility to select courses (Basic course, Basic principles, Relaxation, 1D spatial encoding, Imaging I, Imaging II)

Equipment and technical data

The system includes the following components:

- Control unit:
 - Gradient amplifier and transmitter and receiver unit
 - PC connection USB-B
 - Connection of the imaging unit (gradient) RJ45
 - Connection of the receiver/transmitter unit BNC

- Power supply 12 V DC, 2 A
- Power supply unit (external) 100-240 VAC, 50/60 Hz, 2 A
- Dimensions (cm) 27 x 9.5 x 14
- Weight 2.3 kg
- Magnet unit:
 - High-end gradient system for 2D and 3D images
 - System frequency 22 MHz
 - Field strength 500 mT
 - Field homogeneity < 100 ppm
 - Sample diameter max. 10 mm
 - Connection of the imaging unit (gradient) RJ45
 - Connection of the receiver/transmitter unit BNC
 - Dimensions (length x width x height, cm) 27 x 25 x 14
 - Weight 17.5 kg
- Training software:
 - Languages German/English (other languages on request)
 - Product license measure MRT
 - Data formats DICOM, JPEG, CSV, TXT
 - Media types DVD
- Sample set
 - 5 different samples (water and oil samples each of with 5 and 10 mm diameter, sample with a particular structure)
 - 1 empty sample tube (10 mm)
- Soundbox for a realistic MR-noise
- Connecting cables (2 x RJ45, 1 x BNC, USB)
- Sturdy carrying case and shielded flight box for safe transport
- DVD incl. training software, comprehensive descriptions of the 5 TESS expert experimental units with detailed theoretical background, structured implementation plan, exercises, analyses and many figures clearly arranged, operating instructions, software instructions

Accessories

- Required for the experiments: Computer (min. processor 1.6 GHz) with Windows XP (32-Bit)/Vista (32-Bit)/7, USB 2.0 interface, min. 1 GB RAM, min. of 1 GB hard-disk space, 1024 x 758 graphics card (min. 256 MB, compatible with DirectX 9.0), 16-bit color resolution or better
- Required for MR-noise: active loudspeakers
- Options for experiments: other sample sets or own samples

09500-99



Cross-sectional image of a branch.

P5160200 Ultrasonic echography (A-Scan)

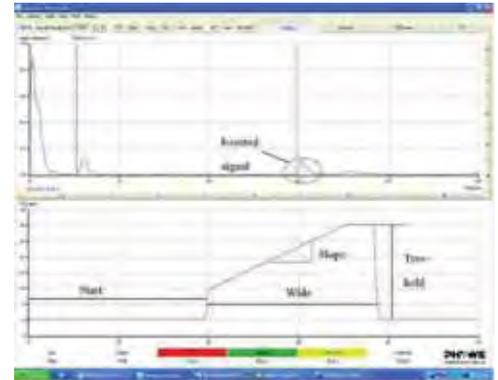


Illustration of the effects of the amplifier or booster settings on the diagram.

Principle

An ultrasonic wave transmitted in a sample will be reflected at discontinuities (defects, cracks). From the relationship between the time of flight of the reflected wave and the sound velocity, the distance between ultrasonic transducer and defects (reflector) can be calculated. Position and size of these defects can be determined by measuring in different directions.

Tasks

1. Measure the longest side of the block with the calliper and the time off light of ultrasound wave for this distance with the 2 MHz probe.
2. Calculate the sound velocity.
3. Measure the position and the size of the different defects of the test block with the calliper and the ultrasound echography method.

What you can learn about

- Propagation of ultrasonic waves; Time of flight; Echo amplitude
- Reflection coefficient; A-scan; Flaw detection
- Non destructive testing (NDT); Ultrasonic transceiver

Main articles

Basic Set Ultrasonic echoscope	13921-99	1
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Related Experiments

Velocity of ultrasound in solid state material

P5160100

Frequency dependence of resolution power

P5160700

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.

13921-99

Ultrasonic echography (B-Scan)

P5160300



NEW



B-Scan image produced with the 2MHz probe.

Principle

The fundamental principles concerning the generation of ultrasonic B-scan images (brightness representation of the reflection amplitudes) are demonstrated with the aid of a simple test object. The experiment is executed with an ultrasonic echoscope in the pulse-echo-mode and the object is scanned manually. Then, the image quality and the most important image defects will be assessed.

Tasks

1. Measure the 3 edge lengths of the test block with a vernier calliper and determine the time of flight of the sound for the various edge lengths of the test block with the aid of the measurement software.
2. Calculate the sound velocity of the test block material and switch the measurement software (A-scan mode) to depth measurement.
3. Produce two B-scans, one with the 1 MHz probe and one with the 2 MHz probe, with the aid of the measurement software (B-scan mode).
4. Measure the depth and width of the echoes in the resulting images.
5. Characterise the quality of the images in terms of their resolution and defects.

What you can learn about

- Sound velocity; Reflection coefficient
- Ultrasonic echography
- A-scan, B-scan; Greyscale display
- Resolution; Zone of focus
- Image artefacts

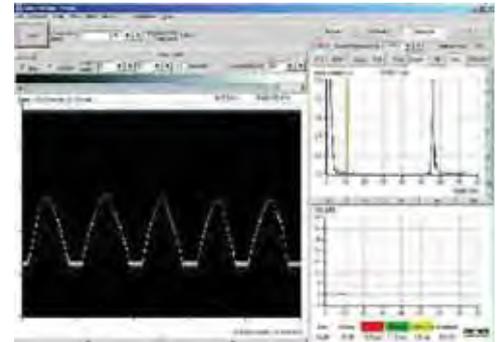
Main articles

Basic Set Ultrasonic echoscope

13921-99 1



P5950200 Ultrasonic Time Motion Mode



Time Motion-mode, slow heart (pump) rate.

Principle

Using a simple heart model, the wall motion is recorded with the ultrasonic time motion method (M-mode or also TM-mode). The heart rate and the cardiac output (CO) are determined from the recorded TM-mode curve.

Tasks

1. Simulate with heart model, the cardiac wall motion and record a time motion-image
2. On basis of the time-motion image, determine the cardiac output and heart rate parameters.

What you can learn about

- Pulse duration (DT)
- Heart rate
- End systolic diameter ESD
- End systolic volume ESV
- Cardiac output (CO)
- Heart wall motion
- Echocardiography
- Time-Motion-Mode
- Representation of motion sequences
- Ultrasonic echography

Main articles

Basic Set Ultrasonic echoscope	13921-99	1
Extension set: medical ultrasonic diagnostics	13921-04	1

Related Experiment

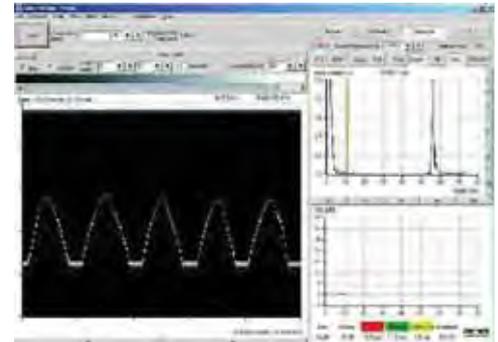
Ultrasonic investigation with eye dummy

P5950400



Ultrasonic investigation with breast dummy

P5950300



Sonographic image of tumour.

Principle

This experiment shows a typical application of ultrasounds in medical diagnostics. A benign tumour on a realistic breast dummy is which has to be diagnosed, localized and measured with an ultrasound cross section imaging method.

Tasks

- Examine the breast dummy and search for any pathological changes. Try to characterize them as accurately as possible (size, location, mobility, strength of the change).
- Produce an ultrasonic B-scan image of the breast dummy, especially in the regions of interest. Based on the ultrasound image, estimate the location and magnitude of the tumour.

What you can learn about

- Breast sonography, tumour size
- Benign tumour, ultrasound imaging procedures
- Ultrasound echography, A-mode, B-mode

Main articles

Basic Set Ultrasonic echoscope	13921-99	1
Extension set: medical ultrasonic diagnostics	13921-04	1

Related Experiment

Ultrasonic investigation with eye dummy

P5950400

Training recommended **Service** | PHYWE

For this experiment we recommend a seminar on equipment technology, handling and information of equipment-specific characteristics on site.

03333-02

Extension set: medical ultrasonic diagnostics

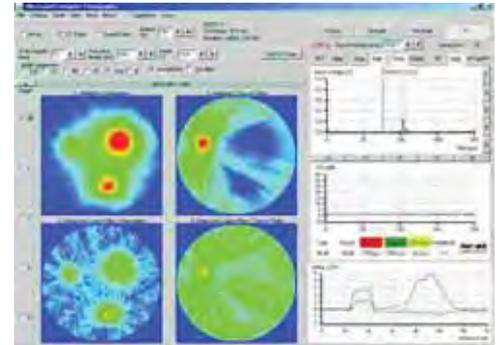


Function and Applications

Kit containing medical models for experimentations in the field of medical diagnostics (echo-cardiography, breast tumour diagnostics and ophthalmology (thickness measurements in the eye)).

13921-04

P5161200 Ultrasonic computertomography



Input of the CT-scan parameters.

Principle

This experiment explains the fundamental principles of the image formation with a CT algorithm. A simple test object is used to create an attenuation tomogram and a time-of-flight tomogram followed by a discussion of the respective differences.

Tasks

1. Creation of several attenuation and time-of-flight tomograms
2. Variation of the device parameters
3. Discussion of the differences

What you can learn about

- Ultrasonic echography (A-scan)
- Tomography
- Resolution

Main articles

Basic Set Ultrasonic echoscope	13921-99	1
Extension Set: CT Scanner	13922-99	1
Ultrasonic probe 2 MHz	13921-05	1

Training recommended Service | PHYWE

For this experiment we recommend a seminar on equipment technology, handling and information of equipment-specific characteristics on site.

03333-02

Extension Set: CT Scanner



Function and Applications

This set is an extension to the ultrasonic pulse echo methods, including automated imaging methods like CT and B mode. With this set the development of a CT image can be demonstrated step by step. Automated B-scan images can be made with this set as well. The scanned objects can be measured and evaluated in axial and lateral direction. The results of the automated measurements with scanner have a much better quality, especially with the imaging methods.

Benefits

For a rather low invest, compared to real life systems, the advantages of mechanical scanning can be demonstrated in a very comprehensible way.

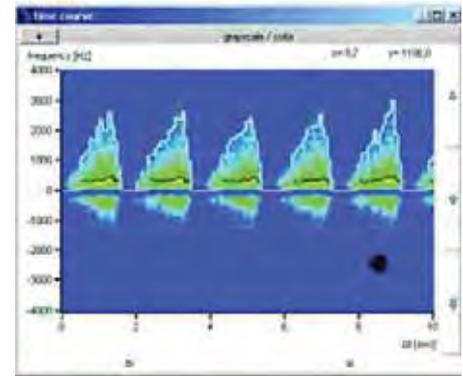
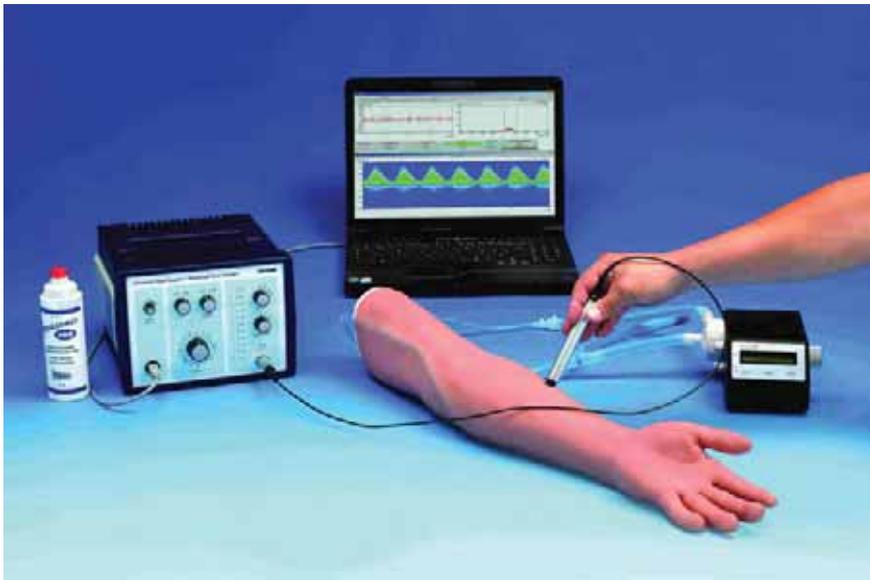
Equipment and technical data

- 1x CT scanner
- 1x CT control unit with tomography software
- 1x Water tank
- 1x CT sample

13922-99

Doppler sonography

P5950100



Typical Doppler signal measured with PHYWE measure Ultra Flow software.

Principle

This set-up shows how blood flow studies are performed using Doppler ultrasound (Doppler sonograph). On a realistic arm dummy, the differences between continuous (venous) and pulsating (arterial) flow are shown as well as the difference in flow through a normal blood vessel and a stenosis.

Tasks

1. Analyse blood flow and search positive and negative flow components. Explain the differences.
2. Locate the built-in stenosis and compare the spectral distribution upstream and downstream of the stenosis.
3. Examine and compare the three pulse modes of the pump.

What you can learn about

- Venous Flow; Arterial flow; Stenosis
- Blood flow velocity tracings; Frequency shift
- Doppler effect; Doppler angle; Doppler sonography
- Colour Doppler; Continuity equation

Main articles

Basic set: Ultrasonic Doppler technique	13923-99	1
Extension Set: medical Doppler Sonography	13923-02	1

Related Experiment

Flow Measurement / Ultrasonic Doppler effect

P5142100

Basic set: Ultrasonic Doppler technique



Function and Applications

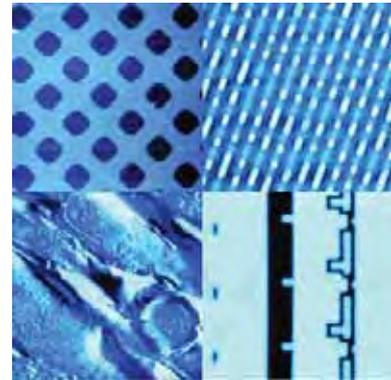
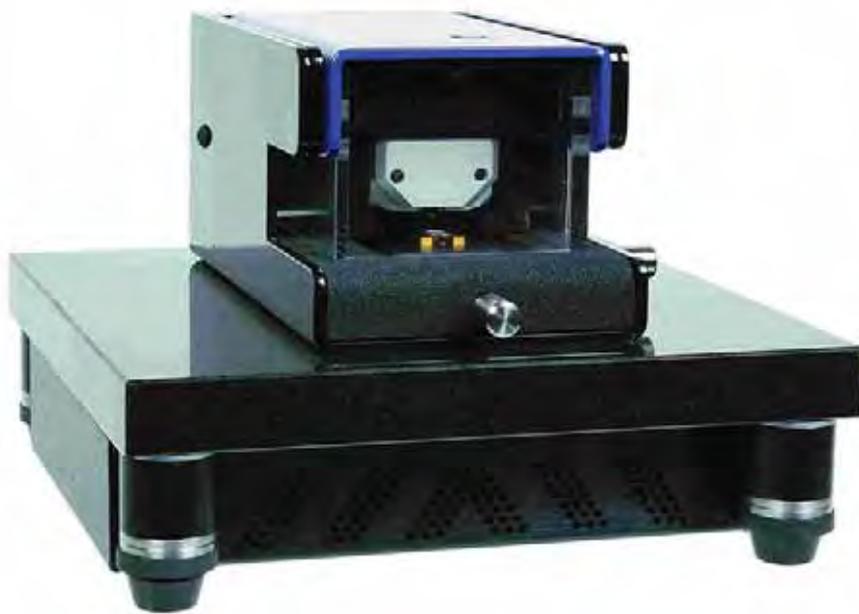
Kit containing instrument and accessories for general ultrasonic sonography experiences. The software displays the measured data from the ultrasonic doppler apparatus, basic instrument of this kit, in realtime on the computer screen. Modular and extendable with accessory kits for experimentations in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

Benefits

- This kit forms a very didactic experimentation system beginning from the basics of sonography and can with accessory kits be extended for the use in specific applications as hydraulics and medical diagnostics (only for training purposes!)
- An experimentation manual is included

13923-99

P2538000 Basic methods in imaging of micro and nanostructures with atomic force microscopy (AFM)



Topography of Microstructure (50 micrometer), CD Stamper (20 micrometer), Skin Cross-Section (60 micrometer), and SCA chip structure (40 micrometer) FLTR.

Principle

Approaching a sharp silicon tip mounted on a cantilever to a sample surface leads to an atomic scale interaction. The results is a bend of the cantilever which is detected by a Laser. In static mode the resulting deflection is used to investigate the topography of the sample surface line-by-line using a feedback loop. In dynamic mode the cantilever is oscillated at fixed frequency resulting in a damped amplitude near the surface. The measurement parameters (setpoint, feedback gain,...) play a crucial role for image quality. The dependence on the imaging quality is investigated for different nano structured samples.

Tasks

1. Set-up the microscope and start up the software. Mount a cantilever (with tip) and approach the tip towards a sample.
2. Investigate the influence of the scanning parameters on the imaging quality and performance, e.g. PID gain, setpoint (force), vibrational amplitude, and scanning speed. Use both static and dynamic force mode.
3. Image 7 different samples (microstructures, carbon nano tubes, skin cross-section, bacteria, CD stamper, chip structure, glass beads) by optimizing the parameters respectively.

What you can learn about

- Atomic Force Microscopy (AFM)
- Lennard-Jones potential
- Imaging of nano structures
- Static Force Mode, Dynamic Force Mode
- Feedback Loop, Force, Vibrational Amplitude

Main articles

Compact-Atomic Force Microscope (AFM) 09700-99 1

Training recommended **Service** PHYWE

For this experiment we recommend a seminar on equipment technology, handling and information of equipment-specific characteristics on site.

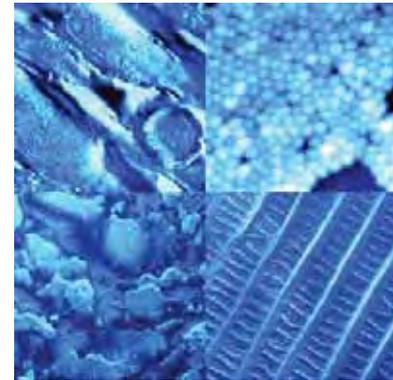
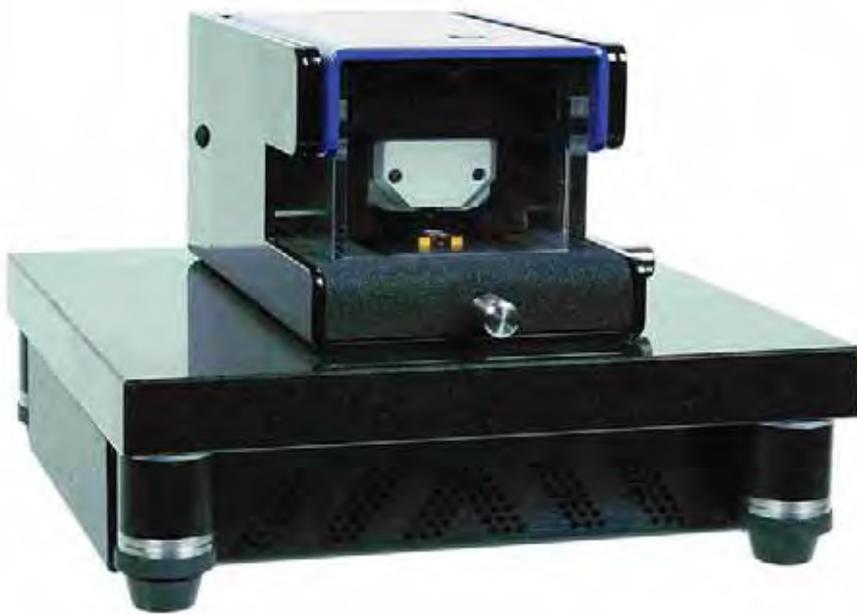
03333-02

You need more information? **WEB@** PHYWE

Just click www.phywe.com

Imaging of biological and medical micro and nanostructure with atomic force microscopy (AFM)

P2538400



Topography of Skin Cross-Section (60 micrometer), Staphylococcus Bacteria (10 micrometer), Human hair (40 micrometer), and Butterfly Wing (10 micrometer) FLTR.

Principle

Dynamic Atomic Force Microscopy is used to image and visualize several biological samples at a sub micrometer scale. A collection of both pre-prepared and freshly prepared samples are investigated, e.g. bacteria, skin cross-section, human hair, butterfly wing, blood cells, and fly eye. With high resolution imaging the relation between small biological structures and their function can be identified and different treatments could be recognized at this scale. One example is the imaging of different skin layers showing dead and living epithelial layer, collagen layer, hair follicle and structures within it. Another example is the imaging of different regular lattice structures to clarify the colour effect of butterfly wings.

Tasks

1. Set-up the microscope and start up the software. Mount a cantilever and approach the tip towards a sample.
2. Use pre-prepared samples and investigate their topography by optimizing the imaging parameters. Discuss the relation between the imaged structures with their function.

- Skin cross-section: different layers and their structures
- Staphylococcus bacteria: form, alignment and surface structure

3. Prepare different samples and investigate their topography by optimizing the imaging parameters. Discuss the relation between the imaged structures with their function and treatment.

- Blood cells: different form and structure, function
- Butterfly wing: different regular structures, interference of light and colour effect

- Fly eye: compound of many "eye" units, resolution, viewing angle, reaction time
- Human hair: treatment dependence of surface structure (coloured and non-coloured, wet and dry)

What you can learn about

- Atomic Force Microscopy
- Dynamic mode, Feedback loop
- High resolution 3D imaging
- Nano Imaging of biological and medical samples
- Relation of structure and function
- Blood Cells; Butterfly Wing; Insect Eye
- Bacteria; Skin; Human hair

Main articles

Compact-Atomic Force Microscope (AFM)	09700-99	1
Sample support, 10 pcs, for Compact Scanning Tunneling Microscope and Atomic Force Microscope	09619-00	1

Training recommended

Service | PHYWE

For this experiment we recommend a seminar on equipment technology, handling and information of equipment-specific characteristics on site.

03333-02

Compact-Atomic Force Microscope (AFM)



Function and Applications

Compact and easy to use atomic force microscope to visualize and image structures on the micro and nano meter scale. Developed for educational purposes in practical lab course and pre-research labs in physics, chemistry, life sciences and material sciences. Also suitable to determine material characteristics (e.g. stiffness, magnetization, charging, material and phase contrast) and for manipulation (e.g. lithography).

Benefits

- Out-of-the-box device with integrated damping plate and control unit underneath
- Complete set, incl. Sample Set, Cantilever, Tools and Consumables
- Tip Scanner AFM for standard cantilever
- Easy and safe cantilever exchange and use: Flip mechanism with automatic laser switch off
- no laser alignment, mechanical stopper for longer lifetime of cantilevers
- Digital top view camera for easy positioning and side view lens for easy and fast approach
- Portable and compact: transportable, easy to install with a small footprint
- Easy to use: ideal for nanotechnology education, preparing students for their work on high-level research devices, and outreach

Equipment and technical Data

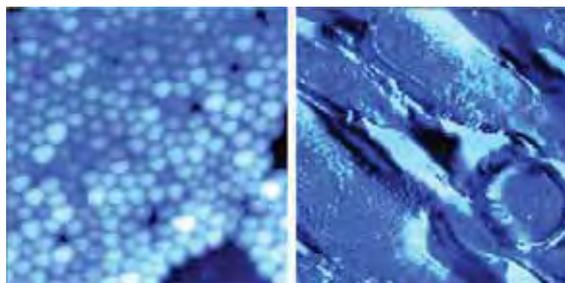
- Scan head with integrated control-unit on vibration-isolated experimentation board: 21cm x 21cm x 18cm, USB 2.0 interface, 16 bit DA converter (XYZ), 16 bit AD converter (7 channels)
- Max scanning speed 60 ms/line, up to 2048x2048 data points
- Scan type (tip scanner): Linear low voltage electro magnetic
- Scan Range: 70 micro meter (1.1 nm resolution)
- Z-range: 14 micro meter (1.1 nm resolution); Z noise level (RMS): 0.6 / 0.5 nm (static / dynamic); Automatic approach: vertical, range 4.5 mm
- Sample: max. 13 mm in diameter, horizontal mount, LED illumination, Micrometer translation stage xy: min. +/- 5 mm
- Cantilever Alignment: automatic adjustment, alignment grooves from various suppliers; Camera system for top view: USB digital colour, 3.1 M pixels
- Modes of operation: Static Force, Dynamic Force, Force Distance Spectroscopy, Amplitude Distance Spectroscopy

- Other modes (MFM,AFM, Phase contrast, lithography and advanced spectroscopy modes) available with upgrade options material and spectroscopy and manipulation
- User expandability (scripting) available (upgrade option); Set of 10 Cantilever, 6 samples, Toolset
- Software for measuring, manipulation, analysing and visualization, Handbook and Quick Installation Guide

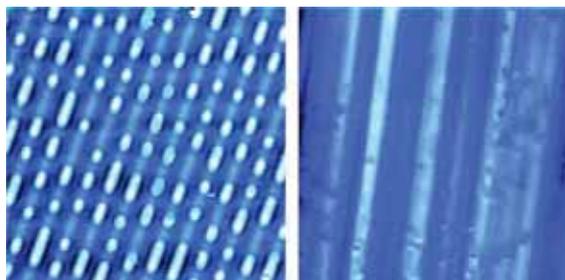
Accessories

- Material upgrade (Art. 09701-00): Additional Operating Modes (Phase Contrast, EFM, MFM, Force Modulation, Spreading Resistance), set of samples and cantilevers
- Spectroscopy and Manipulation upgrade (Art. 09702-00): Additional Operating Modes (Advanced Spectroscopy, Lithography (scratching, oxidation), Manipulation (oxidation, cutting and moving/pushing of nanoparticles), User expandability (Visual basic, LabView, etc.), set of cantilevers and samples
- Side View Camera System (available 2013), other samples

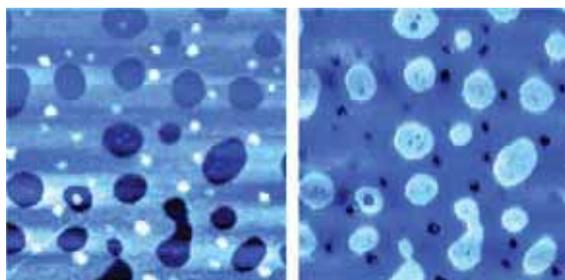
09700-99



Staphylococcus Bacteria, 10 μm and Skin Cross-Section, 60 μm

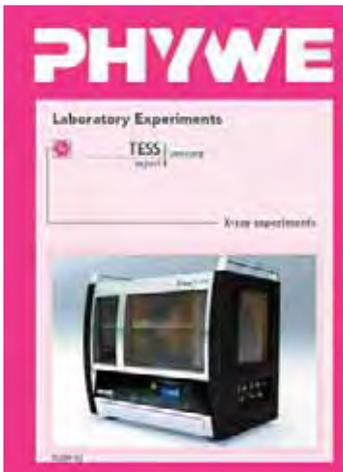


CD Stamper, 20 μm and Aluminum Foil, 60 μm



PS/PMMA films: Topography and Phase Contrast, 3 μm

Laboratory Experiments X-ray experiments



Article no. 01200-02

Experiments with X-rays and their use in physics, chemistry, biology, medicine, material science and geology.

Description

Comprehensive collection of reference experiments concerning the fundamental principles and use of X-rays in physics, chemistry, biology, medicine, material science, and geology with the XR 4.0 X-ray unit platform as a pool of ideas concerning the potential areas of application in demonstration and laboratory experiments.

A clear matrix simplifies the orientation in terms of scientific fields and topics.

Topics

- Characteristic X-radiation / atomic structure / quantum physics and chemistry
- X-ray absorption, Compton scattering, Dosimetry
- Crystal structures/structural analysis with X-rays/Debye-Scherrer experiments (counting tube goniometer)
- Transirradiation experiments/non-destructive testing

Features

- Experiment descriptions with clearly structured learning objectives, fundamental principles, photo of the set-up, equipment list, tasks, illustrated instructions concerning the set-up and procedure, theory and evaluation with example results plus important notes concerning the operation and safety of the equipment.
- This simplifies the orientation and execution as well as the selection of the experiment parts for personalised laboratory experiments. The information provided is so comprehensive that no other background information is required.
- For every experiment, the software package "XRM 4.0 measure X-ray" includes presettings for the easy and direct execution of the experiment at the push of a button as well as numerous example measurements.
- Experiment matrix for quick orientation
- Operating instructions concerning the components of the XR 4.0 platform including detailed information
- DIN A4 format, spiral-bound
- Colour print

This documentation contains the following experiments:

Counter tube characteristics

P2540010

Radiographic examination of objects

P2540020

Qualitative examination of the absorption of X-rays

P2540030

Ionizing effect of X-radiation

P2540040

Characteristic X-rays of copper

P2540101

Characteristic X-rays of iron

P2540301

The intensity of characteristic X-rays as a function of the anode current and anode voltage

P2540401

K alpha doublet splitting of iron X-rays / fine structure

P2540801

Duane-Hunt displacement law and Planck's "quantum of action"

P2540901

Characteristic X-ray lines of different anode materials / Moseley's law

P2541001

Absorption of X-rays

P2541101

K and L absorption edges of X-rays / Moseley's law and the Rydberg constant

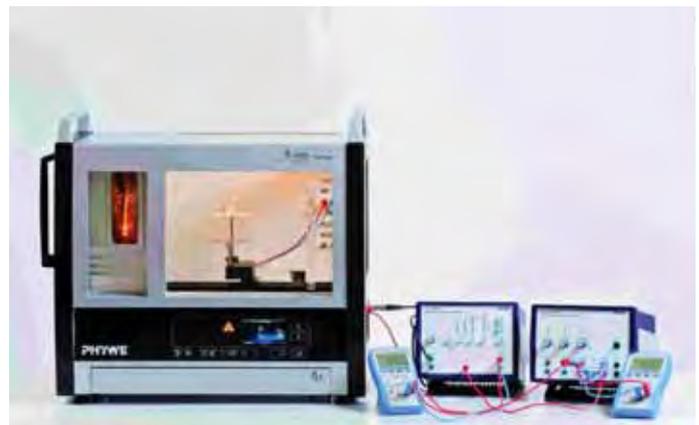
P2541201

Examination of the structure of NaCl monocrystals with different orientations

P2541301

Complete experiment list see www.phywe.com

01200-02



P2541801 - X-ray dosimetry

Laboratory Experiments Application of ultrasounds in medicine, material sciences and industry



Article no. 01232-02

Description

19 detailed experiment guides

Topics

- Medical diagnostics
 - Echography / Mammosonography
 - Echography / Ultra sonic biometry
 - Echo-cardiography
 - Doppler-sonography
 - Ultrasonic computerized tomography (CT)
- Material sciences / Physics
 - A-scan, B-scan
 - Velocity and attenuation of ultrasound in solid state material
 - Shear waves
 - Focus zone, Resolution power
 - Non-destructive testing (NDT) (Detection of discontinuities, angle beam measurement, Time of flight diffraction (TOFD))
 - Mechanical scan methods, Ultrasonic computerized tomography (CT)
- Fluid dynamics
 - Laws of flow, Flow measurements
 - Level measurement

Features

- Experimental guides with clearly structured learning objectives, fundamental principles, photo of the set-up, equipment list, tasks, illustrated instructions concerning the set-up and procedure, theory and evaluation with example results plus important notes concerning the operation and safety of the equipment. In most cases no other background information is required.
- DIN A4 format, spiral-bound, colour print, 200 pages
- Incl. operating manuals
- Experiment guides in english

01232-02

Laboratory Experiments Magnetic Resonance Tomography (MRT) Applications in physics, biology, chemistry and medicine



Article no. 01233-02

Description

Comprehensive collection of experiments regarding the magnetic resonance (MR) technology. The manual comprises basic experiments of the MR physics as well as experiments on complex MR imaging (2D and 3D). Experiments are didactically and precisely prepared and convey all relevant information about magnetic resonance tomography. Through questions, answers, evaluations and a comprehensive theory students are guided and are able to learn one of the most important procedures of medical diagnostics with a lot of fun and enjoyment. The software needed to perform the experiments perfectly fits the experimental literature and thus enables an unique learning and teaching experience. For example parameters can be directly varied during a measurement ("on runtime").

The manual is suitable for almost all fields of science. However, basically it is aimed at students with a deep medical background.

Topics

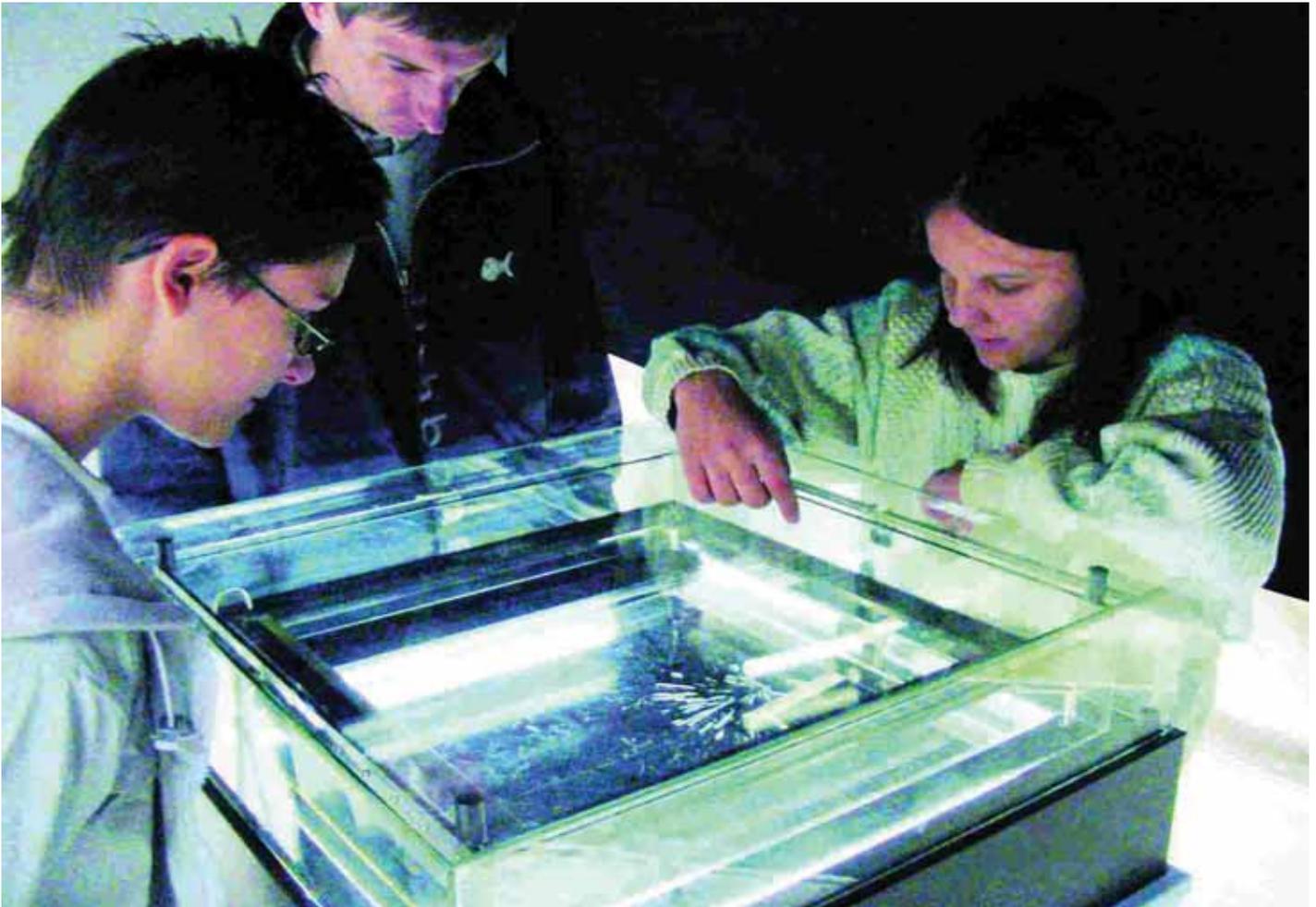
The manual consist of five TESS expert experimental units (P5942100-P5942500). Each unit consists of a multitude of single experiments and covers a very specific topic of MR physics and MR diagnostics.

- basic principles in nuclear magnetic resonance (NMR)
- relaxation times in nuclear magnetic resonance
- spatial encoding in nuclear magnetic resonance
- magnetic resonance imaging I (Spin Echo 2D, Flash 2D)
- magnetic resonance imaging II (Localized Spin Echo 2D and 3D)

Features

- Experimental descriptions with a clear division in related topics, principle, equipment, set-up, questions, tasks, illustrated implementation related to the tasks, theory with many coloured figures and all necessary contents to process the questions and tasks, evaluation with exemplary results, and important notes for operation and safety.

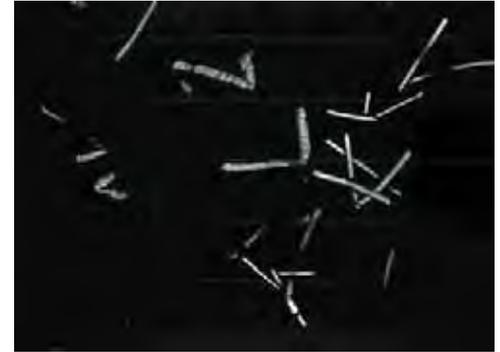
01233-02



Nuclear Medicine

5.1	Visualisation of Radioactive Particles	86
5.2	Radioactive Decay	87
5.3	Absorption and Dosimetry	88

P2520400 Visualisation of radioactive particles with the diffusion cloud chamber PJ45



Particles visible in the diffusion cloud chamber.

Principle

Radioactivity is a subject in our society which has been playing an important role throughout politics, economy and media for many years now.

The fact that this radiation cannot be seen or felt by the human being and that the effects of this radiation are still not fully explored yet, causes emotions like no other scientific subject before.

The high-performance diffusion cloud chamber serves for making the tracks of cosmic and terrestrial radiation visible so that a wide range of natural radiation types can be identified.

Furthermore, the diffusion cloud chamber offers the opportunity to carry out physical experiments with the aid of artificial radiation sources.

Tasks

1. Determination of the amount of background radiation
2. Visualisation of α , β , γ -particles and mesons
3. Visualisation of the Thorium (Radon) decay
4. Deflection of β -particles in a magnetic field

What you can learn about

- α , β , γ -particles; β -deflection
- Ionising particles; Mesons
- Cosmic radiation; Radioactive decay
- Decay series; Particle velocity
- Lorentz force

Main articles

Diffusion cloud chamber, 45 x 45 cm PJ45, 230 V	09046-93	1
Radioactive source Sr-90, 74 kBq	09047-53	1

Alternatively

Diffusion cloud chamber 80 x 80 cm, PJ 80, 230 V

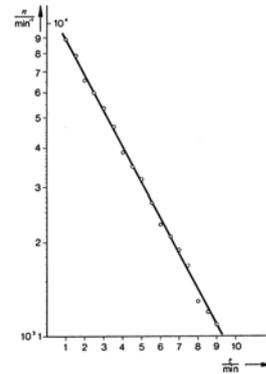
09043-93



C.T.R. Wilson
1927, Nobel Prize in Physics

Half-life and radioactive equilibrium

P2520101



Logarithmic plot of the counting rate of the eluted daughter substance as a function of time.

Principle

The half-life of a Ba-137 m daughter substance eluted (washed) out of a Ca-137 isotope generator is measured directly and is also determined from the increase in activity after elution.

Tasks

1. To record the counting rate as a function of the counter tube voltage (counter tube characteristic) when the isotope generator activity is constant (radioactive equilibrium).
2. To measure the activity of the isotope generator as a function of time immediately after elution.
3. To measure the activity of a freshly eluted solution of Ba-137 m as a function of time.

What you can learn about

- Parent substance
- Daughter substance
- Rate of decay
- Disintegration or decay constant
- Counting rate
- Half life
- Disintegration product

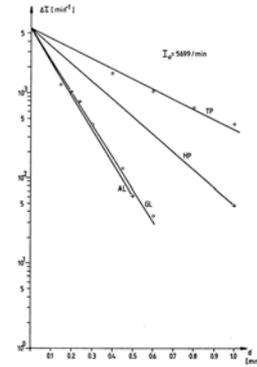
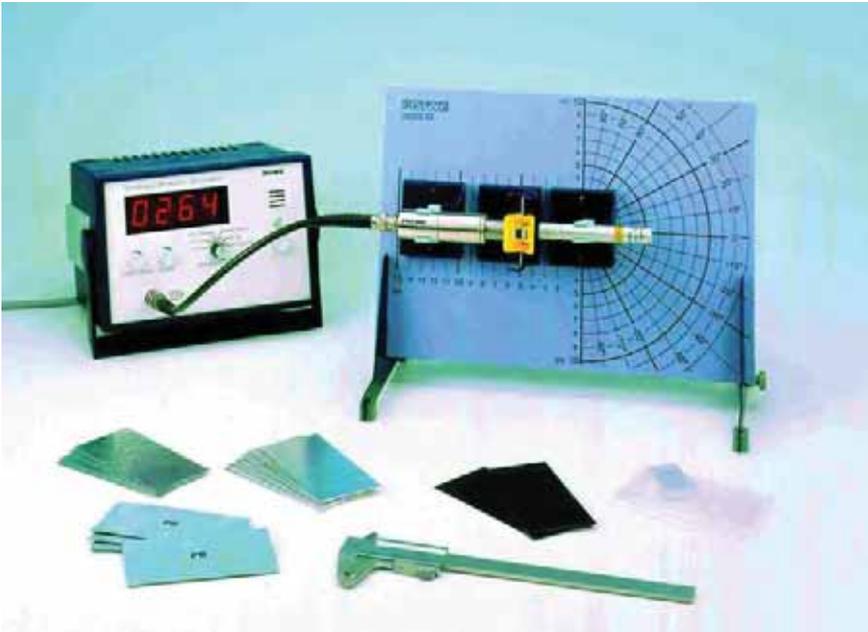
Main articles

Isotope generator Cs-137, 370 kBq	09047-60	1
Pulse rate meter	13622-93	1
Geiger-Mueller Counter tube, type A, BNC	09025-11	1
Digital multimeter 2010	07128-00	1
Base plate for radioactivity	09200-00	1
Plate holder on fixing magnet	09203-00	1
Counter tube holder on fix. magn.	09201-00	1



Marie Curie
1903, Nobel Prize in Physics

P2523100 Electron absorption



Counting rate I as a function of absorber thickness.

Principle

The attenuation of an electron particle stream passing through a material layer depends both on the thickness of the layer and on the mass coverage, resp. the "mass per unit area". It will be shown that the particle flux consisting of electrons of a particular energy distribution decreases with the "mass per unit area". As electron source, a radioactive sample of Sr-90 is used.

Tasks

1. The beta-counting rates are measured as a function of the absorber thickness using different absorbing materials such as aluminium (AL), glass (GL), hard paper (HP), and typing paper (TP).
2. The attenuation coefficients are evaluated for the four absorbing materials and plotted as a function of the density.

What you can learn about

- Density
- Counter tube
- Radioactive decay
- Attenuation coefficient
- Mass coverage

Main articles

Radioactive source Sr-90, 74 kBq	09047-53	1
Geiger-Mueller-Counter	13606-99	1
Geiger-Mueller Counter tube, type A, BNC	09025-11	1
Absorption plates f. beta-rays	09024-00	1
Base plate for radioactivity	09200-00	1
Plate holder on fixing magnet	09203-00	1
Counter tube holder on fix. magn.	09201-00	1

Geiger-Mueller-Counter



Function and Applications

Demonstration and student use unit in connection with Geiger Mueller counting tubes for experiments on radioactivity.

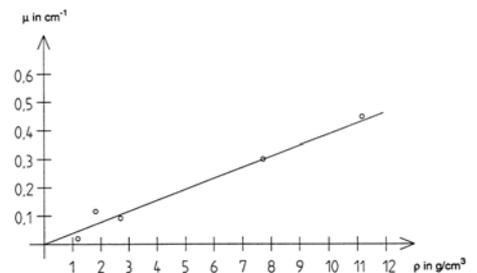
Equipment and technical data

- 4-digit LED display, 20 mm high
- 4 standard measurement times 1/10/60/100 s
- Automatic measurement sequence with memory 10 s
- Freely selectable measuring time
- BNC-socket for counting tube 500 V
- 4-mm-bushes for event counting with TTL signals
- Mains 100-230 V/50-60 Hz
- Shock proof casing with carrying handle
- Dimensions 190 x 140 x 130 mm

13606-99

Inverse-square law and absorption of gamma or beta rays with the Geiger-Müller counter

P2524101



Attenuation coefficient of different materials as a function of the material density (from left to right: Plexiglas®, concrete, aluminium, iron, lead).

Principle

The inverse square law of distance is demonstrated with the gamma radiation from a ⁶⁰Co preparation, the half-value thickness and absorption coefficient of various materials determined with the narrow beam system and the corresponding mass attenuation coefficient calculated.

Tasks

1. To measure the impulse counting rate as a function of the distance between the source and the counter tube.
2. To determine the half-value thickness $d_{1/2}$ and the absorption coefficient of a number of materials by measuring the impulse counting rate as a function of the thickness of the irradiated material. Lead, iron, aluminium, concrete and Plexiglas are used as absorbers.
3. To calculate the mass attenuation coefficient from the measured values.

What you can learn about

- Radioactive radiation
- β -decay
- Conservation of parity
- Antineutrino
- Gamma quants
- Half-value thickness
- Absorption coefficient
- Term diagram
- Pair formation
- Compton effect
- Photoelectric effect
- Conservation of angular momentum
- Forbidden transition
- Weak interaction
- Dead time

Main articles

Radioactive sources, set	09047-50	1
Geiger-Mueller-Counter	13606-99	1
Geiger-Mueller Counter tube, type A, BNC	09025-11	1
Absorption material, lead	09029-01	1
Absorption plates f. β -rays	09024-00	1
Absorption material, concrete	09029-05	1
Plate holder on fix. magnet	09204-00	1
Absorption material, aluminium	09029-03	1
Base plate for radioactivity	09200-00	1
Absorption material, iron	09029-02	1

Radioactive sources, set

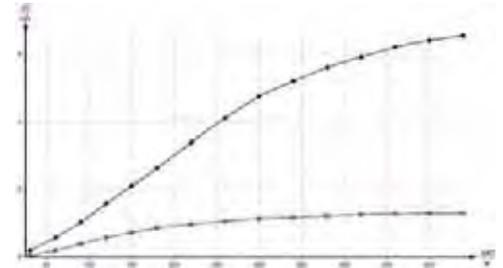


Function and Applications

Set of 4 encapsulated radionuclides, radiation sources with storage container.

09047-50

P2541801 X-ray dosimetry



Ionisation current I_c as a function of the capacitor voltage U_c for different diaphragm tubes.

Principle

Dosimetry, as a subspecialty of medical physics, deals with the determination and calculation of dose rates, which is also of great importance in view of the radiation protection directives. This experiment demonstrates the principle of measurement and it explains the various units of absorbed dose, equivalent dose, and absorbed dose rate. Inside a plate capacitor, an air volume is irradiated with X-rays. The resulting ion current is used to determine the dosimetric data.

Tasks

- Using the two different diaphragm tubes and the fluorescent screen, the given distance between the aperture and the radiation source at maximum anode voltage and current is to be determined.
- The ion current at maximum anode voltage is to be measured and graphically recorded as a function of the capacitor voltage by using two different beam limiting apertures. The ion dose rate and the energy dose rate are to be determined from the saturation current values.
- Using the $d = 5 \text{ mm}$ aperture, the ion current is to be determined and graphically recorded at various anode currents but with maximum anode and capacitor voltages.
- The ion current is to be measured and graphically recorded as a function of the capacitor voltage at different anode voltages and the corresponding saturation currents plotted graphically.

What you can learn about

- X-rays
- Absorption inverse square law
- Ionizing energy
- Energy dose
- Equivalent dose and ion dose and their Rates
- ϱ -factor
- Local ion dose rate
- Dosimeter

Main articles

XR 4.0 expert unit	09057-99	1
XR 4.0 X-ray plug-in unit W tube	09057-80	1
DC measuring amplifier	13620-93	1
Power supply, 0...600 VDC	13672-93	1
XR 4.0 X-ray Capacitor plates f. X-ray-unit	09058-05	1

Related X-ray Experiment

Ionizing effect of X-radiation

P2540040

Best fitting X-ray sets for this experiment:

XRE 4.0 X-ray expert set

09110-88

XRD 4.0 X-ray dosimetry upgrade set

09170-88



Laboratory Diagnostics

6.1	Standards and Methods	92
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6.5	Further Basic Methods	115

TESS expert Clinical chemistry and haematology–

Teaching package for medical education

Haematology and clinical chemistry are standard topics for medical analysis in hospitals. Practical courses figure in the curriculae throughout the world as well as for students in medicine as for medical laboratory technicians.

TESS expert Clinical chemistry and haematology provide full practical laboratory courses including equipment, consumables and handbook. Experimental literature for up to 22 experiments includes basic experiments dealing with the skills of lab work and theory (dilution, statistics etc.) to facilitate the interpretation of analytical results and the preparation of lab reports.

Further topics such as photometry (determination of cholesterol and sugar), coagulation, blood cell counting, blood typing etc. are treated among others so that the students get all skills they need for the work in clinical laboratories and for corresponding diagnostics.

Remarks concerning local standards are included in the experimental description.

Features

- Complete teaching package, compact storage
- Detailed descriptions for up to 22 experiments with separate lab reports
- Preliminary experiments for basic lab skills and statistics
- Haematology
- Microscopy
- Photometry
- Coagulation
- Blood cell count
- Blood typing



TESS expert Medicine Set Clinical Chemistry and Haematology, basic set for one workgroup



Function and Application

The sets clinical chemistry and hematology provide full practical courses consisting of consumables, equipment and handbook. The experiments are designed for both the practical courses in medicine at the university and for the education of assistant medical technicians.

Benefits

- The sets include kinetic measurements, photometric determinations and all the examinations for the complete blood count.
- The detailed and intuitive descriptions are suitable to be used directly by students in practical courses.
- The students get experienced in handling for example blood samples, photometers, coagulometers and microscopes - in other words: they get all skills they need for the work in clinical laboratories and the interpretation of the results of lab diagnostics.

Selection of theme fields:

- Complete blood count
- Special experiment for the diagnosis of malaria
- Erythrocyte sedimentation rate
- Kinetic measurements
- Coagulation: prothrombin ratio and partial thromboplastin time
- Quantitative analysis of blood glucose and other blood parameters
- Examination of urine

Content

- Microscope
- Accessories for microscopy
- First set of consumption items (gloves, pipette tips...)
- Microliterpipette dig. 10-100 µl
- Microliterpipette dig. 200-1000 µl
- Counting chamber according to Neubauer

Additionally needed:

- Set for 3-5 workgroups (13951-88)
- Chemicals, Set for up to 12 Workgroups (Art. No. 13952-88)
- Test kits for clinical chemistry (to be purchased on local markets)

Described experiments:

Set Basics experiments

- Geometric dilution series (5910100)
- Standard deviation and variation coefficient (P5910200)
- Recording an extinction curve (P5910300)

Set Clinical experiments

- Coagulation: Determination of Partial Thromboplastin Time (P5911000)
- Coagulation: Quick-test (P5911100)
- Determination of Total Protein (5911200)
- Determination of Blood Glucose (P5911300)
- Determination of Cholesterol (P5911400)
- Determination of CRP (P5911500)
- Determination of CHE (P5911600)
- Determination of Creatinine (P5911700)
- Semiquantitative Urine analysis by Means of Test Stripes (P5911800)
- Analysis of Urinary Sediment (P5911900)

Set Haematology

- Erythrocyte Sedimentation Reaction (5921000)
- Determination of Haematocrit (5921100)
- Determination of Haemoglobin (P5921200)
- Erythrocyte Count (P5921300)
- Leucocyte count (P5921400)
- Differential Blood Count (P5921500)
- Manual Thrombocyte Count (P5921600)
- Determination of ABO and Rhesus Blood Groups(P5921700)
- Malaria (P5921800)

13950-88

TESS expert Medicine Set Clinical Chemistry and Haematology, Lab equipment for 3-5 work groups

Function and Application

The sets clinical chemistry and hematology provide full practical courses consisting of consumables, equipment and handbook. The experiments are designed for both the practical courses in medicine at the university and for the education of assistant medical technicians.

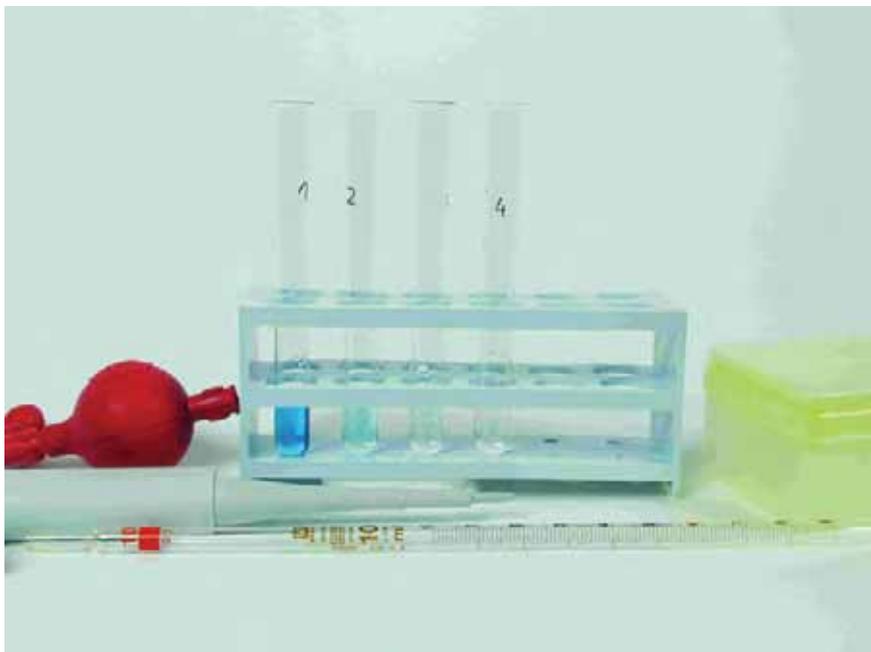
13951-88

TESS expert Medicine Set Clinical Chemistry and Haematology, Chemicals for up to 5 students groups

Chemicals for the experimentation sets TESS expert Medicine Clinical Chemistry and Haematology (13950-88, 13951-88).

13952-88

P5910100 Geometric dilution series



Schematic diagram of the procedure.

Principle

A dilution series is started with a solution in a defined concentration, which is then continuously diluted by a defined factor. The solution obtained in this manner is then used as the starting point for the next solution.

Tasks

1. Perform a geometric dilution series with a Giemsa-solution.
2. Calculate the concentration and the mixing ratio of the solutions obtained.

What you can learn about

- Straight calibration line
- Dilution
- Mixing ratio

Main articles

Microliterpipette dig. 100-1000 µl	47141-05	1
Azur-eosin-meth. blue soln. 100 ml	31070-10	1
Disposable gloves, 100 pcs, medium	46359-00	1
Test tube rack, plastic, demont.	46235-00	1
Pipettor	36592-00	1
Pipette tips, 50-1000 µl, racked	47148-12	1
Graduated pipette 10 ml	36600-00	1

Microliterpipette dig. 100-1000 µl



Function and Applications

Pipette with air pad.

47141-05

This experiment is included in the TESS Sets „Clinical Chemistry and Haematology“ (See page 92f).

TESS expert Medicine Set Clinical Chemistry and Haematology, basic set for one workgroup

13950-88

Standard Deviation and variation coefficient

P5910200



NEW

$$s = \sqrt{\frac{\sum(x_i - \text{mean value})^2}{n - 1}}$$

Formula for standard deviation.

Principle

The standard deviation indicates the spread of the measured values around their own mean value. It is a statistical value, serving the purpose of discovering random errors. The variation coefficient is the relative standard deviation. Both values are an integral part of statistical quality control. The function of statistical quality control is the detection of errors in the performance of quantitative analyses.

Task

Determine the extinction of four individually prepared solutions of the same concentration and subsequently calculate the standard deviation and the variation coefficient.

What you can learn about

- Quality control
- Standard deviation
- Variation coefficient

Main articles

Filter photometer 400 to 700 nm	35602-99	1
Microliterpipette dig. 10-100 µl	47141-03	1
Semi-micro cuvettes 1.5 ml, 100 pcs	35662-10	1
Azur-eosin-meth.blue soln. 100 ml	31070-10	1
Test tube rack, plastic, demont.	46235-00	1
Pipette tips, 2-200 µl, racked	47148-11	1

Filter photometer 400 to 700 nm**Function and Applications**

The Biochrom WPA C07000 is a portable colorimeter designed for use by doctors and medical technologists in small and medium sized clinics. Single beam filter based spectrophotometer/colorimeter covering 400 to 700 nm.

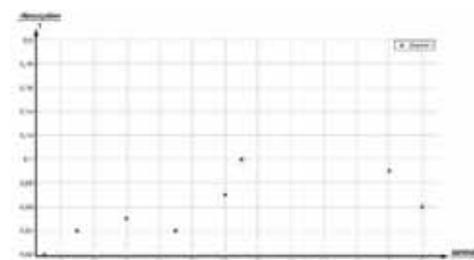
35602-99

This experiment is included in the TESS Sets „Clinical Chemistry and Haematology“ (See page 92f).

TESS expert Medicine Set Clinical Chemistry and Haematology, basic set for one workgroup

13950-88

P5910300 Recording of an extinction curve



Extinction curve.

Principle

Initially, a dye solution is prepared and subsequently extinction is measured at different wave lengths. Following that, the values obtained can be used to compile an extinction curve.

Task

Compile the extinction curve of a Giemsa-solution.

What you can learn about

- Photometry
- Extinction
- Dilution
- Extinction curve

This experiment is included in the TESS Sets „Clinical Chemistry and Haematology“ (See page 92f).

TESS expert Medicine Set Clinical Chemistry and Haematology, basic set for one workgroup

13950-88

Main articles

Filter photometer 400 to 700 nm	35602-99	1
Microliterpipette dig. 10-100 µl	47141-03	1
Microliterpipette dig. 100-1000 µl	47141-05	1
Semi-micro cuvettes 1.5ml, 100 pcs	35662-10	1
Azur-eosin-meth. blue soln. 100 ml	31070-10	1
Test tube rack, plastic, demont.	46235-00	1
Pipettor	36592-00	1
Test tube, 110x12 mm, 100 pcs	37655-10	1

Coagulation: Quick-test

P5911100



Semi-logarithmic paper.

Principle

The Quick test is a coagulation analysis and is performed as screening test. The coagulation time according to Quick (also described as thromboplastin time) is a measure for the content of coagulation factors of the exogenous system (VII, X, II, I). The coagulation time is determined with the aid of a coagulometer. Due to the fact that the thromboplastin time is measured in seconds but indicated in %, we additionally require a calibration line, which will also be described in this experiment.

Tasks

1. Compile a calibration line from a dilution series and use this to determine the Quick value of a patient sample and a control sample.
2. Calculate the deviation of the individual measured value of the control sample.
3. Calculate the International Normalized Ratio.

What you can learn about

- Plasmatic coagulation
- Exogenous activation path
- Quick/thromboplastin time
- Coagulometer

Main articles

Coagulometer	45063-99	1
Microliterpipette dig. 10-100 µl	47141-03	1
Microliterpipette dig. 100-1000 µl	47141-05	1
Starter set for coagulometer	45063-01	1
Microtubes, disposable, 1.5 ml, 1000/pkg	37653-00	1
0,9% NaCl- solution	31618-10	1

Related Experiment

Coagulation: Determination of Partial Thromboplastin Time

P5911000

This experiment is included in the TESS Sets „Clinical Chemistry and Haematology“ (See page 92f).

TESS expert Medicine Set Clinical Chemistry and Haematology, basic set for one workgroup

13950-88

P5911200 Determination of Total Protein



NEW



Procedure: Preparation of the samples.

Principle

The determination of total protein from plasma, serum, urine or liquor in this experiment is carried out photometrically with the aid of the biuret reaction. In this reaction, bivalent copper ions attach to the peptide bonds of the proteins, indicating the protein content by colour reaction.

Tasks

1. Determine the protein concentration in the serum sample and in the control sample.
2. Determine the protein content of a urine or liquor sample.
3. Calculate the deviation of the individual measured value of the control sample.

What you can learn about

- Proteins
- Amino acids
- Peptides
- Photometry
- Biuret reaction
- Hypoproteinaemias and Hyperproteinaemias

Main articles

Centrifuge w. angle rotor 8x15 ml	65973-93	1
Filter photometer 400 to 700 nm	35602-99	1
Microliterpipette dig. 10-100 µl	47141-03	1
Microliterpipette dig. 100-1000 µl	47141-05	1
Semi-micro cuvettes 1.5 ml, 100 pcs	35662-10	1
Centrifuge tube, 15 ml, 10 off	65973-02	1
Trichloroacetic acid 19.4 %	31909-10	1

Centrifuge with angle rotor 8x15 ml



Function and Applications

Centrifuge with angle rotor.

65973-93

This experiment is included in the TESS Sets „Clinical Chemistry and Haematology“ (See page 92f).

TESS expert Medicine Set Clinical Chemistry and Haematology, basic set for one workgroup

13950-88

Quantitative Determination of Blood Glucose

P5911300



NEW



Measuring the blank value.

Principle

Blood sugar is the key energy provider for our cells. The primary hormone in blood sugar regulation is insulin. The glucose oxidase/peroxidase method for the determination of blood sugar introduced here is also applied in multiple test strips for the determination of glucose in the urine. In this method, the glucose oxidase (GOD) is used to oxidize glucose by the oxygen in the air to gluconic acid. The H₂O₂ generated in this process reacts, by action of peroxidase (POD), with a colour indicator and is converted into a dye which is detectable by photometry.

Tasks

1. Determine the glucose concentration in the blood of a patient and in a control sample.
2. Calculate the deviation of the individual measured value of the control sample.

What you can learn about

- Glucose
- Glucose oxidase/Peroxidase method
- Photometry
- Diabetes mellitus

Main articles

Filter photometer 400 to 700 nm	35602-99	1
Microliterpipette dig. 10-100 µl	47141-03	1
Microliterpipette dig. 100-1000 µl	47141-05	1
Semi-micro cuvettes 1.5 ml, 100 pcs	35662-10	1
Cuvette rack, PE, 16 places	35661-10	1

This experiment is included in the TESS Sets „Clinical Chemistry and Haematology“ (See page 92f).

TESS expert Medicine Set Clinical Chemistry and Haematology, basic set for one workgroup

13950-88

P5911400 Determination of Cholesterol



Four samples are measured as follows: blank value, standard sample, control sample, patient sample.

Principle

Cholesterol is a constituent of all biological membranes and thus an essential lipid. Increased cholesterol levels represent a major risk factor for arteriosclerotic angiopathy, particularly coronary heart disease. The cholesterol concentration in a blood sample is determined photometrically by colour indicator reaction.

Tasks

1. Determine the cholesterol content of a serum sample and a control sample.
2. Calculate the associated deviation of the individual measured value of the control sample.

What you can learn about

- Cholesterol
- Lipoproteins
- Photometry
- Hyperlipidaemia

Main articles

Filter photometer 400 to 700 nm	35602-99	1
Microliterpipette dig. 10-100 µl	47141-03	1
Microliterpipette dig. 100-1000 µl	47141-05	1
Semi-micro cuvettes 1.5 ml, 100 pcs	35662-10	1
Pipettor	36592-00	1
Cuvette rack, PE, 16 places	35661-10	1
Pipette tips, 50-1000 µl, racked	47148-12	1

This experiment is included in the TESS Sets „Clinical Chemistry and Haematology“ (See page 92f).

TESS expert Medicine Set Clinical Chemistry and Haematology, basic set for one workgroup

13950-88

Determination of CRP (C-reactive protein)

P5911500



Reaction vessel number	1	2	3	4	5	6
0.9% NaCl-solution (µl)	—	50	50	50	50	50
Serum (µl)	100	—	—	—	—	—
Transfer diluted serum and mix (µl)	—	50 +	50 +	50 +	50 +	50
Dilution (fold)	1:1	1:2	1:4	1:8	1:16	1:32

Serum dilution series.

Principle

The determination of CRP (CRP: C-reactive protein) represents an important test for the detection of inflammatory reactions. The determination is qualitative, on the basis of serum, and/or semi-quantitative on the basis of a latex-agglutination test. The test is based on an immunochemical reaction between CRP-molecules and CRP-antibodies, which are linked to latex particles.

Tasks

1. Perform a qualitative latex agglutination test.
2. Estimate the CRP-concentration of a patient sample semi-quantitatively by means of a dilution series.

What you can learn about

- C-reactive protein
- Agglutination test
- Inflammations
- Antibodies
- Titre

Main articles

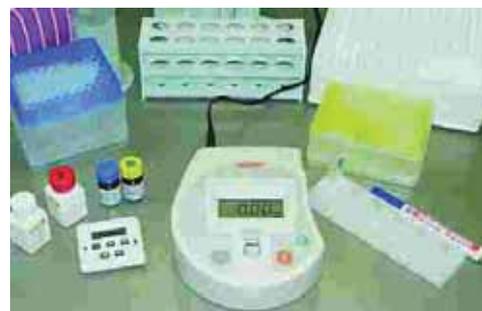
Microliterpipette dig. 10-100 µl	47141-03	1
Microliterpipette dig. 100-1000 µl	47141-05	1
Microtubes, disposable, 1.5ml, 1000/pkg	37653-00	1
0,9% NaCl- solution	31618-10	1
Test tube rack, plastic, demont.	46235-00	1
Pipette tips, 50-1000 µl, racked	47148-12	1
Pipette tips, 2-200 µl, racked	47148-11	1

This experiment is included in the TESS Sets „Clinical Chemistry and Haematology“ (See page 92f).

TESS expert Medicine Set Clinical Chemistry and Haematology, basic set for one workgroup

13950-88

P5911600 Determination of CHE (cholinesterase)



Test set-up and determination of the blank value.

Principle

The determination of CHE (CHE: cholinesterase) is of great diagnostic value for checking the synthesis capacity of the liver, investigation of the suitability for anaesthesia, in case of poisoning with insecticides like parathion, synonym: E 605, as well as disorders of the intestines involving the loss of proteins. In this test, the enzyme activity of the pseudocholinesterases (PCH) in a sample is determined by kinetic measurement.

Tasks

1. Determine the PCH-enzyme activity of a serum sample and a control sample.
2. Compare the individual measured value of the control sample with the internal error limits of the laboratory or the normal range of the control sample as shown in the list of target values.

What you can learn about

- Cholinesterases
- Pseudocholinesterase
- Principle of kinetic measurements
- Photometer
- Enzyme activity

Main articles

Filter photometer 400 to 700 nm	35602-99	1
Microliterpipette dig. 10-100 µl	47141-03	1
Microliterpipette dig. 100-1000 µl	47141-05	1
Semi-micro cuvettes 1.5 ml, 100 pcs	35662-10	1
Test tube rack, plastic, demont.	46235-00	1
Cuvette rack, PE, 16 places	35661-10	1

This experiment is included in the TESS Sets „Clinical Chemistry and Haematology“ (See page 92f).

TESS expert Medicine Set Clinical Chemistry and Haematology, basic set for one workgroup

13950-88

Determination of Creatinine

P5911700



Measuring workflow.

Principle

Creatinine is generated as a metabolite of the muscle metabolism, in relation to the muscle mass, and is excreted with the urine. Increased creatinine levels are found in acute kidney failure, chronic kidney insufficiency and hypoperfusion of the kidneys. Analysis of the creatinine concentration is performed photometrically with Jaffé's method. Creatinine is suitable as a clearance substance because creatinine is excreted through the kidneys at a rate of 99 %. The creatinine clearance is determined on the basis of the creatinine concentration in the serum and 24h-urine, taking the quantity collected and the time of collection into account.

Tasks

1. Determine the creatinine content in a serum-urine sample as well as in the control sample.
2. Calculate the associated deviation of the individual measured value of the control sample.
3. Calculate the creatinine clearance for your patient.

What you can learn about

- Creatinine
- Clearance
- Kidney function
- Photometry
- Jaffé's reaction

Main articles

Filter photometer 400 to 700 nm	35602-99	1
Microliterpipette dig. 10-100 µl	47141-03	1
Microliterpipette dig. 100-1000 µl	47141-05	1
Semi-micro cuvettes 1.5ml, 100 pcs	35662-10	1
Pipettor	36592-00	1

This experiment is included in the TESS Sets „Clinical Chemistry and Haematology“ (See page 92f).

TESS expert Medicine Set Clinical Chemistry and Haematology, basic set for one workgroup

13950-88

P5911800 Semiquantitative Urine analysis by Means of Test Strips



Sample test result of urine analysis.

Principle

The analysis of urine by means of test strips serves the purpose of early detection of potential disorders of the kidneys and the genitourinary system (e.g. urinary tract infections, stones, tumours, glomerulonephritis, pyelonephritis) and primarily non-renal diseases like diabetes mellitus, insufficiency of the liver, acute intravascular haemolysis and others. The test strips indicate specific density, pH-value, the content of nitrite, glucose, urobilinogen and bilirubin as well as the occurrence of leucocytes, proteins, ketones and blood.

Tasks

1. Assess a urine sample macroscopically for colour, clarity and smell.
2. Analyse a urine sample by means of the urine test strips and interpret the result.

What you can learn about

- Urine analysis
- Multiple test strips
- Glucosuria
- Leucocyturia
- Proteinuria

Main articles

Urine test strip	31352-00	1
Disposable gloves, 100 pcs, medium	46359-00	1
Test tube rack, plastic, demont.	46235-00	1
Digital stop watch, 24 h, 1/100 s & 1 s	24025-00	1

This experiment is included in the TESS Sets „Clinical Chemistry and Haematology“ (See page 92f).

TESS expert Medicine Set Clinical Chemistry and Haematology, basic set for one workgroup

13950-88

Analysis of Urinary Sediment

P5911900



Masses of erythrocytes.

Principle

The analysis of urinary sediment is an in-depth analysis in case of a pathological test strip finding showing positive test results for leucocytes, erythrocytes, protein, nitrite or a pH>7. Erythrocytes, epithelia, cylinders, bacteria, trichomonadas, fungi and crystals are detected and identified with the aid of a microscope.

Task

1. Produce a urine sediment specimen from a suitable urine sample.
2. Examine the sediment components under the microscope.

Related topics

- Urine
- Urates
- Trichomonadas
- Bacteria
- Cylinders
- Epithelia
- Leukocytes
- Erythrocytes

Main articles

Centrifuge w. angle rotor 8x15 ml	65973-93	1
Microscope 1820, binoc.	62194-93	1
Microliterpipette dig. 10-100 µl	47141-03	1
Centrifuge tube, 15 ml, 10 off	65973-02	12
Test tube rack, plastic, demont.	46235-00	1
Pipettor	36592-00	1
Pipette tips, 2-200 µl, racked	47148-11	1

Semiquantitative Urine analysis by Means of Test Strips

Principle

The analysis of urine by means of test strips serves the purpose of early detection of potential disorders of the kidneys and the genitourinary system (e.g. urinary tract infections, stones, tumours, glomerulonephritis, pyelonephritis) and primarily non-renal diseases like diabetes mellitus, insufficiency of the liver, acute intravascular haemolysis and others. The test strips indicate specific density, pH-value, the content of nitrite, glucose, urobilinogen and bilirubin as well as the occurrence of leucocytes, proteins, ketones and blood.

P5911800

This experiment is included in the TESS Sets „Clinical Chemistry and Haematology“ (See page 92f).

TESS expert Medicine Set Clinical Chemistry and Haematology, basic set for one workgroup

13950-88

P5921000 Erythrocyte Sedimentation Reaction (ESR)



Procedure: Reading of the sedimentation.

Principle

Measurement of the erythrocyte sedimentation rate is an unspecific detection test in case of suspected inflammatory diseases. Also in tumours, para-proteinaemias, dysproteinaemias and amyloidosis, ESR will be increased. In this experiment, the so-called manual Westergren method is used.

Task

Determine the erythrocyte sedimentation rate of a blood sample.

What you can learn about

- Erythrocytes; Westergren method

Main articles

Blood sedimentation apparatus (ESR)	45062-00	1
Sodium citrate sol, 100 ml	45062-10	1
Sedimentation pipettes, 10 pcs	45062-03	1
Special rubber caps for Westergren pipettes 15 pcs	45062-04	1
Digital stop watch, 24 h, 1/100 s & 1 s	24025-00	1

This experiment is included in the TESS Sets „Clinical Chemistry and Haematology“ (See page 92f).

TESS expert Medicine Set Clinical Chemistry and Haematology, basic set for one workgroup

13950-88

Blood sedimentation apparatus (ESR)



Function and Applications

Apparatus for determination of blood sedimentation speed (ESR) according to Westergren, macro-method, 3 places.

Benefits

- Support made of steel
- Tilting device for rapid method

Equipment and technical data

- Support with 3 places
- Pipettes for ESR, 3 pcs
- Mixing bottle with rubber stopper, 3 pcs

45062-00

Determination of Haematocrit

P5921100



Reading against the template.

Principle

The haematocrit value is the relative percentage by volume of erythrocytes in the overall blood volume. In this experiment, it is determined by centrifugation of a heparinized whole blood sample in a capillary.

Task

Determine the haematocrit value of a blood sample.

What you can learn about

- Haematocrit
- Erythrocytes
- Anaemia
- Haemoglobin

Main articles

Centrifuge w. angle rotor 8x15 ml	65973-93	1
Master plate for hematocrit	45061-02	1
Sealing putty for capillary tubes, 2 pcs	45061-01	1

This experiment is included in the TESS Sets „Clinical Chemistry and Haematology“ (See page 92f).

TESS expert Medicine Set Clinical Chemistry and Haematology, basic set for one workgroup

13950-88

Centrifuge with angle rotor 8x15 ml



Function and Applications

Centrifuge with angle rotor.

Equipment and technical data

- Contin. speed adjustm max. 6000 U/min
- Connection voltage 230 V / 50-60 Hz
- Power requirement 60 W
- Overheating protection
- Impulse key for short runs
- Gravity acceleration max. 3420 g
- Transparent lid with lock
- Weight 4,0 kg
- Dimensions: 216x231x292 mm

65973-93

P5921200 Determination of Haemoglobin



Reading of the extinction.

Principle

Quantitative haemoglobin determination is indispensable for the diagnosis of anaemias. For this purpose, the haemoglobin contained in a certain volume of blood is determined. In our experiment, the cyanmethaemoglobin method is used. The concentration of haemoglobin (Hb) in whole blood is determined after transformation into stable cyanhaemoglobin. At 540 nm, cyanhaemoglobin presents an absorption band which is suitable for the determination of haemoglobin.

Task

Determine the haemoglobin concentration of a sample with the aid of the cyanmethaemoglobin method.

What you can learn about

- Erythrocytes; Photometry
- Haemoglobin; Cyanohaemoglobin
- Oxyhaemoglobin; Carboxyhaemoglobin
- Methaemoglobin; Anaemia

Main articles

Filter photometer 400 to 700 nm	35602-99	1
Microliterpipette dig. 10-100 µl	47141-03	1
Semi-micro cuvettes 1.5ml, 100pcs	35662-10	1
Transformation solution for determination of haemoglobin	31899-70	1
Pipettor	36592-00	1
Cuvette rack, PE, 16 places	35661-10	1
Pipette tips, 2-200 µl, racked	47148-11	1

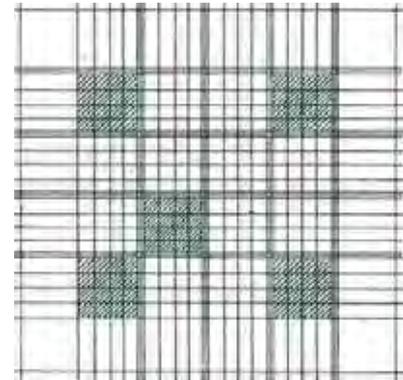
This experiment is included in the TESS Sets „Clinical Chemistry and Haematology“ (See page 92f).

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13950-88

Erythrocyte Count

P5921300



Neubauer chamber, internal counting reticle.
The 5 group squares with the 16 basic squares which are to be counted are highlighted with a grey background.

Principle

In this experiment, erythrocytes are counted manually in a counting chamber under the microscope.

Tasks

Determine the number of erythrocytes in a sample.

What you can learn about

- Erythrocytes
- Leucocytes
- Thrombocytes

Main articles

Microscope 1820, binoc.	62194-93	1
Microliterpipette dig. 10-100 µl	47141-03	1
Microliterpipette dig. 100-1000 µl	47141-05	1
Counting chamber according to Neubauer	64697-00	1
Microtubes, disposable, 1.5 ml, 1000/pkg	37653-00	1
Pipette tips, 50-1000 µl, racked	47148-12	1
Pipette tips, 2-200 µl, racked	47148-11	1

Related Experiments

Manual Leucocyte Count

P5921400

Differential Blood Count

P5921500

Manual Thrombocyte Count

P5921600

This experiment is included in the TESS Sets „Clinical Chemistry and Haematology“ (See page 92f).

TESS expert Medicine Set Clinical Chemistry and Haematology, basic set for one workgroup

13950-88

P5921500 Differential Blood Count



Principle

In manual blood counts, a droplet of blood is spread on a slide in such a manner that the cells are located separately, side by side in one layer. After application of the Pappenheim's stain, the cells can be classified individually by size, nucleus-plasma relation, shape and structure of nucleus, colour and granulation of cytoplasm. The erythrocytes will be assessed as well.

Tasks

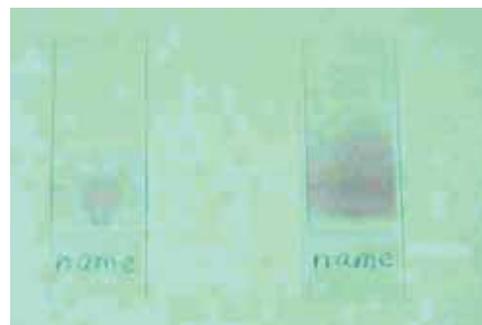
Examine a stained blood sample by microscope and differentiate the leucocytes.

What you can learn about

- Erythrocytes
- Leucocytes
- Pappenheim's stain

Main articles

Microscope 1820, binocular	62194-93	1
Buffer tablets pH 7.2 for microscopy	30284-10	1
Staining bench with vat	64534-00	1
Methanol, tech. gr. 1000 ml	30142-70	1
Azur-eosin-meth.blue solution 100 ml	31070-10	1
Volumetric flask 1000 ml, IGJ24/29	36552-00	1
Immersion oil, 50 ml	31381-05	1
May-Grunwald solution	31562-70	1



Left = Smear too thin and too short; right = Correct size and thickness.

TESS expert Medicine Handbook Clinical Chemistry and Haematology

Description

Comprehensive collection of experiments concerning clinical chemistry and hematology. A clear matrix simplifies the orientation in terms of scientific fields and topics.

Topics

- Determination of cholesterol and blood glucose
- Differential blood count
- Agglutination
- Hematocrite
- Malaria
- Urine analysis

01230-02

This experiment is included in the TESS Sets „Clinical Chemistry and Haematology“ (See page 92f).

TESS expert Medicine Set Clinical Chemistry and Haematology, basic set for one workgroup

13950-88

Manual Thrombocyte Count

P5921600



Filling the Neubauer chamber.

Principle

Thrombocytes are counted in a Neubauer chamber, under the microscope. For this purpose, the erythrocytes, which would otherwise interfere, are haemolysed with a hypotonic ammonium oxalate solution and the thrombocytes are isolated and rounded. This analysis is part of the regular blood count.

Tasks

Determine the number of thrombocytes of a blood sample.

What you can learn about

- Erythrocytes
- Thrombocytes
- Neubauer chamber

Main articles

Microscope 1820, binoc.	62194-93	1
Microliterpipette dig. 10-100 µl	47141-03	1
Microliterpipette dig. 100-1000 µl	47141-05	1
Counting chamber according to Neubauer	64697-00	1
Thrombo-Count-Reagent	31898-05	1
Microtubes, disposable, 1.5 ml, 1000/pkg	37653-00	1
Pipette tips, 50-1000 µl, racked	47148-12	1

Microscope 1820, binoc.



62194-93

This experiment is included in the TESS Sets „Clinical Chemistry and Haematology“ (See page 92f).

TESS expert Medicine Set Clinical Chemistry and Haematology, basic set for one workgroup

13950-88

P5921700 Determination of ABO and Rhesus Blood Groups



Pipetting blood specimen.

Principle

With the discovery of the blood groups of the ABO-system by Karl Landsteiner in 1900 and the Rh-system in 1940, it has been possible to carry out blood transfusions with high success rates for the first time. A precise determination of the blood group prior to the transfusion is essential for the recipient. Banked blood which is not matched properly may cause haemolysis of the erythrocytes and lead to the death of the recipient. ELDONCARDTM2511 is a primary test for erythrocyte antigens.

Tasks

1. Determine the blood group in an EDTA-blood specimen.
2. Determine the blood group in a capillary blood specimen.

What you can learn about

- Blood groups
- ABO-system
- Antigen
- Rhesus antigen
- Monoclonal antibodies

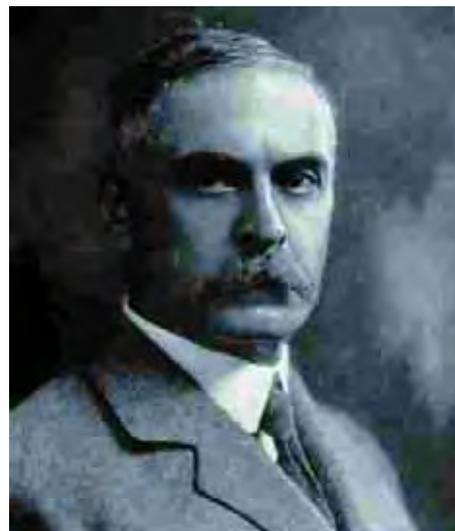
Main articles

Microliterpipette dig. 10-100 µl	47141-03	1
Eldon cards for Blood grouping	87973-01	1
Pipette tips, 2-200 µl, racked	47148-11	1

This experiment is included in the TESS Sets „Clinical Chemistry and Haematology“ (See page 92f).

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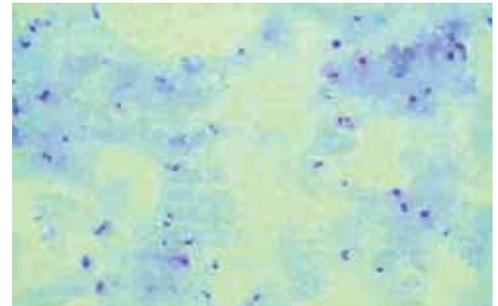


Karl Landsteiner

1930, Nobel Prize in Medicine

Malaria

P5921800



Thick drop with plasmodia.

Principle

Malaria is caused by plasmodia. The disease is transmitted via the female form of the anopheles mosquito. Plasmodium falciparum is the pathogenic agent of the tropical disease malaria tropica, which is the most dangerous form of malaria. The thick drop method is applied to diagnose not only malaria but also other parasitic diseases such as sleeping sickness. Various forms of the pathogenic agent and typical signs such as Maurer's spots and Schüffner's dots are easier to detect in a complementary differential blood count.

Tasks

1. Diagnose malaria by means of the thick drop method.
2. Determine the pathogen density and differentiate the plasmodia by means of a differential blood count.

What you can learn about

- Plasmodium falciparum
- Malaria tropica
- Erythrocytes
- Pappenheim's stain

Main articles

Microscope 1820, binoc.	62194-93	1
Buffer tablets pH 7.2 for microscopy	30284-10	1
Staining bench with vat	64534-00	1
Methanol, tech.gr. 1000 ml	30142-70	1
Azur-eosin-meth.blue soln. 100 ml	31070-10	1
Volumetric flask 1000ml, IGJ24/29	36552-00	1
Immersion oil, 50 ml	31381-05	1

This experiment is included in the TESS Sets „Clinical Chemistry and Haematology“ (See page 92f).

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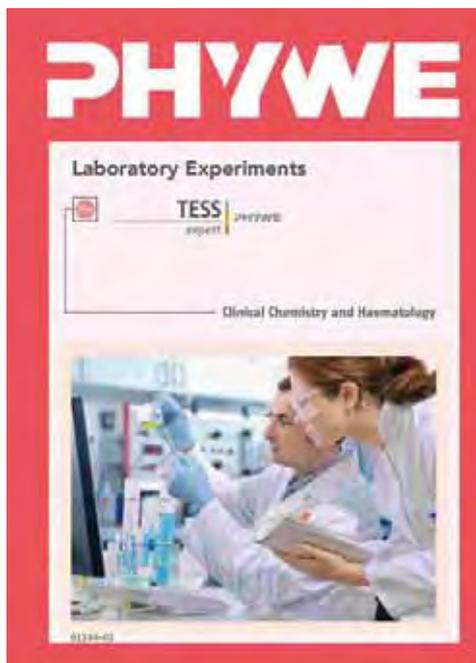
13950-88



Ronald Ross

1902, Nobel Prize in Physiology or Medicine

TESS expert Medicine Handbook Clinical Chemistry and Haematology



Article no. 01230-02

Description

Comprehensive collection of experiments concerning clinical chemistry and hematology. A clear matrix simplifies the orientation in terms of scientific fields and topics.

Topics

- Determination of cholesterol and blood glucose
- Differential blood count
- Agglutination
- Hematocrite
- Malaria
- Urine analysis

Features

Experiment descriptions with clearly structured learning objectives, fundamental principles, photo of the set-up, equipment list, tasks, illustrated instructions concerning the set-up and procedure, theory and evaluation with example results plus important notes concerning the operation and safety of the equipment. This simplifies the orientation and execution as well as the selection of the experiment parts for personalised laboratory experiments. The information provided is so comprehensive that no other background information is required.

DIN A4 format, spiral-bound, colour print

This documentation contains the following experiments:

Geometric Dilution Series

P5910100

Standard Deviation and Variation Coefficient

P5910200

Recording of an Extinction curve

P5910300

Coagulation: Determination of Partial Thromboplastin Time
P5911000

Coagulation: Quick Test
P5911100

Determination of Total Protein
P5911200

Quantitative Determination of Blood Glucose
P5911300

Determination of Cholesterol
P5911400

Determination of CRP
P5911500

Determination of CHE
P5911600

Determination of Creatinine
P5911700

Semiquantitative Urinalysis by Means of Test Strips
P5911800

Analysis of Urinary Sediment
P5911900

Erythrocyte Sedimentation Reaction (ESR)
P5921000

Determination of Haematocrit
P5921100

Determination of Haemoglobin
P5921200

Erythrocyte Count
P5921300

Manual Leucocyte Count
P5921400

Differential Blood Count
P5921500

Manual Thrombocyte Count
P5921600

Determination of ABO and Rhesus Blood Groups
P5921700

Malaria
P5921800

01230-02

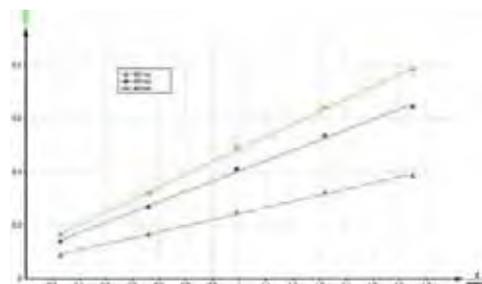
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Distribution equilibrium

P3030701



Relationship between extinction E and concentration c for trans-azobenzene in acetonitrile at different wavelengths.

Principle

At constant temperature and under constant pressure, a dissolved substance distributes itself between two immiscible liquids in a constant concentration ratio. This ratio is equal to the partition coefficient (distribution coefficient) of the substance examined in the given two-phase system.

Tasks

1. Measure the extinction of various concentrated solutions of *trans*-azobenzene in acetonitrile at constant wavelength. Subsequently determine the equilibrium concentrations (extinctions) of *trans*-azobenzene in the system *n*-heptane / acetonitrile after single and repeated distribution at constant temperature.
2. Calculate the partition coefficients and effectiveness of the extractions from the experimental data and compare them.

What you can learn about

- Principles of thermodynamics
- Partial molar free enthalpy (chemical potential)
- Equilibrium between phases; Distribution and extraction
- Nernst distribution equation; Lambert-Beer law
- Photometry

Main articles

Set of Precision Balance Sartorius CPA 623S and measure software, 230 V	49224-88	1
Spectrophotometer S800, 330...800 nm	35600-99	1
Cells for spectrophotometer	35664-02	1
Separatory funnel 1000 ml	35850-04	1
Thermometer -10...+50 C	38034-00	1

Spectrophotometer S800, 330...800 nm



Function and Applications

This visible diode array spectrophotometer has been designed to meet the routine spectroscopy needs of customers requiring a small, lightweight instrument that is easy to use. This photometer is ideal for use in educational, biotech or industrial establishments.

Benefits

- It measures absorbance, % transmission, absorbance ratio and concentration.
- The large backlit graphical display enables wavelength scans, kinetic assays (including slope calculation) and standard curves to be viewed.

35600-99

P3070101 Absorption of light (UV-VIS spectroscopy)



Plot of the absorption maxima of methyl orange against the relative dielectric constants of different solvents.

Principle

The structures of molecules are not changed by their chemical environment in the gas phase. In contrast to this, on transition to the condensed phase, in dilute solution, the solvent changes the binding state of the dissolved substance. One of the way this influence makes itself shown is in the electron spectrum (solvatochromatic shift).

Tasks

1. Plot and discuss UV-visible absorption spectra of methyl orange in various solvents.
2. From the decadic molar extinction coefficients of the bands in the visible range, determine the type of electron transition that causes these bands.
3. Plot the wavelengths of the absorption maxima in the visible range against the dielectric constants of the various solvents.

What you can learn about

- Absorption of light
- Electron excitation
- Influence of solvents
- Solvatochromic, hypsochromic and bathochromic shifts
- Lambert-Beer's Law
- Decadic molar extinction coefficient

Main articles

Spectrophotometer 190-1100 nm	35655-93	1
Set of Precision Balance Sartorius CPA 623S and measure software, 230 V	49224-88	1
Cells for spectrophotometer, quartz, 2 pcs.	35665-02	1
Micro-l syringe, 100 micro-l	02606-00	1
N,N-Dimethylformamide, puriss., 1 l	31259-70	1
Ethyl alcohol, absolute 500 ml	30008-50	1

Spectrophotometer 190-1100 nm



Function and Applications

Spectrophotometer 190-1100 nm.

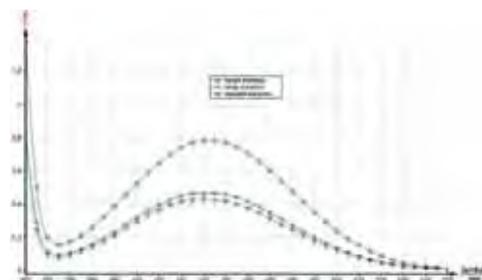
Benefits

- The UV-VIS spectral photometer is characterised by its compact design and due to its wide range of possible uses.
- Operation is via a clearly set out overlay keyboard on the screen dialogue.
- Current wavelengths and measured values can be displayed in large format.

35655-93

Excitation of molecules

P3070301



Absorption spectrum of carotene in acetone.

Principle

The position of the longest wavelength $\pi - \pi^*$ -absorption band in the UV-visible spectrum of organic compounds which have chromophoric systems can be approximately calculated by various methods. For dyes with extended conjugated π -systems, the model of the electron in a unidimensional potential box (confinement region) supplies results that agree sufficiently well with experimental results.

Tasks

1. Plot the absorption spectrum of carotene, a polyene dye, in the visible range of electromagnetic radiation.
2. Compare the wavelength of the absorption maximum determined from this with the value calculated from the representation of the electron in a unidimensional box.
3. Discuss this comparison.

What you can learn about

- Wave mechanics atomic model
- Model of electrons in a unidimensional potential box
- Ground and excitation states of molecules
- Electron excitation spectroscopy (UV-visible spectrometry)
- Spectroscopical energy and adsorption measurement
- Chemical theory of colour; Lambert-Beer's Law
- Photometry; Chromatography

Main articles

Spectrophotometer 190-1100 nm	35655-93	1
Sec.bottle 500ml, 2xGl18/8, 1x25/12	34170-01	1
Cells for spectrophotometer, optical glass	35664-02	1
Spring manometer, 0...1000 mbar	34170-02	1
Water jet pump, plastic	02728-00	1
Thermometer -10...+50 C	38034-00	1

Related Experiment

Absorption spectra and pKa values of p-methoxyphenol

P3070401

Measurespec spectrometer with cuvette holder and light source



Function and Applications

This set consisting of a Measurespec spectrometer (35610-00) and a cuvette holder and light source for the Measurespec (35610-99) makes it possible to record both emission and absorption spectra. The light to be investigated is guided by optical fibres to a grid fixed inside the spectrometer, which disperses it into its spectral colours. The spectrum is recorded with the aid of a CCD array, which records the entire spectrum at once, making it possible to reliably record rapid changes in the spectrum itself. The spectra can be displayed and stored by means of the supplied software with its versatile functionality. The spectrometer is connected to a PC via a USB port, which also suffices to supply power to the spectrometer, so that no additional supply is needed. The cuvette holder holds standard cuvettes measuring 1 cm x 1 cm. The built-in light source makes it possible to record absorption spectra for solutions. The rapid measuring rate of the spectrometer even allows the speed of reactions involving changes in colour to be measured (reaction kinetics). Light having passed through the cuvette is guided into the spectrometer via optical fibre. Fibres for fluorescence measurements can also be attached at 90° to the path of the incident light.

Benefits

Spectrometer:

- Robust aluminium case
- Rapid measurement of full spectral range
- Flexible introduction of light to be investigated by means of optical fibres
- No additional power supply required
- Measurement of emission spectra and absorption spectra
- Intuitive "measure" software for controlling the apparatus and recording spectra

Cuvette holder:

- Robust aluminium case
- Long-lived tungsten lamp
- Flexible introduction of light to be investigated by means of optical fibres
- Universal power supply via plug-in transformer

- Measurement of absorption spectra, fluorescence spectra, reaction kinetics

Equipment and technical data

Spectrometer:

- Supplied with software and optical fibres
- Range of wavelengths: 350...850 nm
- Detector: silicon CCD array
- Resolution: 4 nm
- Connection to computer: USB
- Optical fibre connection: SMA 905
- Dimensions (mm): 170 x 126 x 55

Cuvette holder:

- Supplied with plug-in power supply and optical fibres
- Type of lamp: tungsten (lifetime approx. 2000 hours)
- Optical fibres: 50 µm x 2 m
- 2 optical fibre connectors: SMA 905
- Size of cuvettes: 1 cm x 1 cm
- Power supply: 100 ... 240 V / 50 ... 60 Hz
- Dimensions (mm): 95 x 51 x 46

Accessories

Matching cuvettes:

- Cuvettes for spectral photometer, optical glass, 12 x 12 x 45 mm, set of 2 (35664-02)
- Polystyrene macro-cuvette, 12 x 12 x 44 mm, 4 ml, set of 100 (35663-10)

35610-88

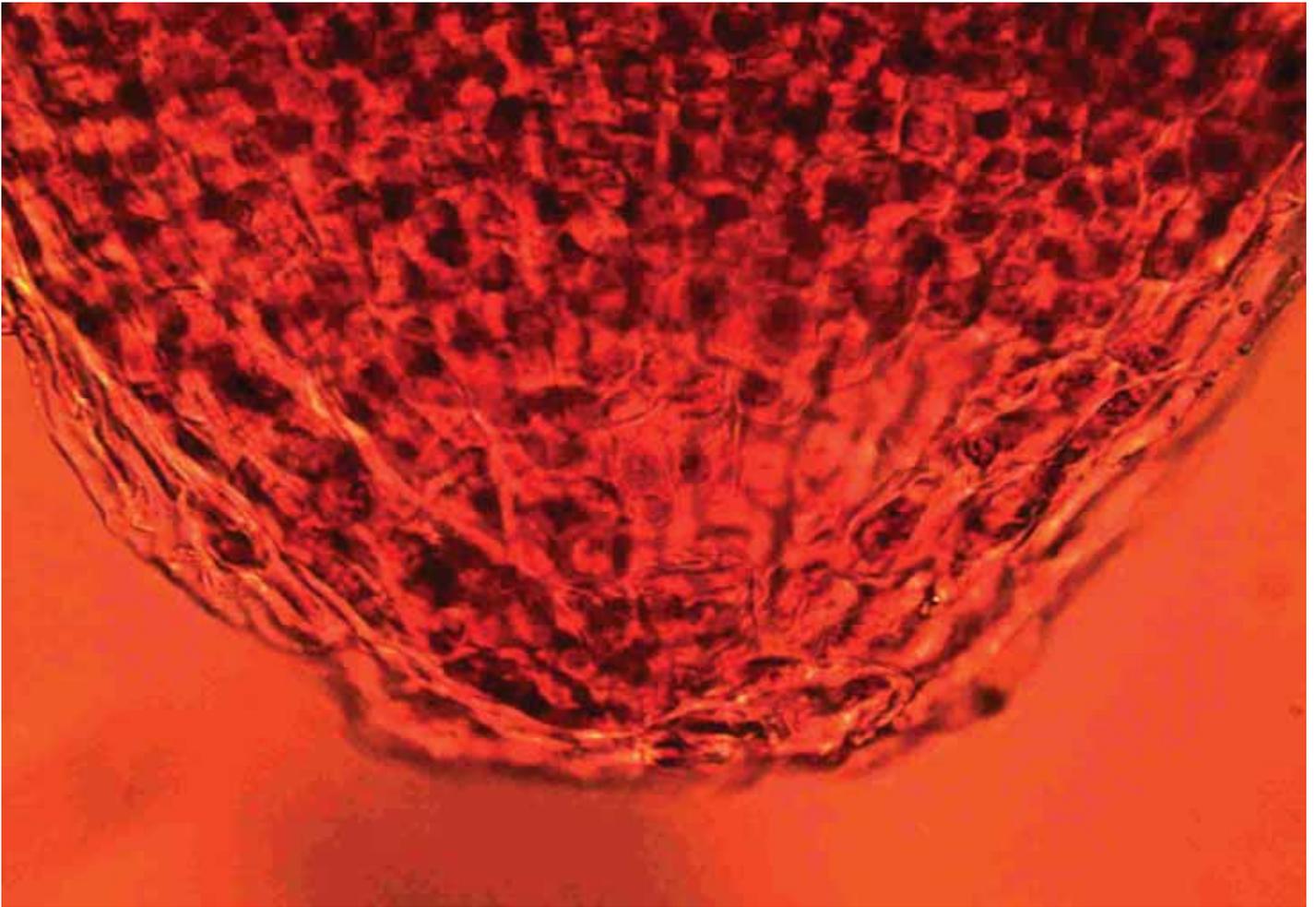
Cuvette holder with light source for spectrometer



Function and Applications

Supplement to Measurespec spectrometer. The cuvette holder holds standard cuvettes measuring 1 cm x 1 cm. The built-in light source makes it possible to record absorption spectra for solutions. The rapid measuring rate of the spectrometer even allows the speed of reactions involving changes in colour to be measured (reaction kinetics). Light having passed through the cuvette is guided into the spectrometer via optical fibre. Fibres for fluorescence measurements can also be attached at 90° to the path of the incident light.

35610-99



Histology and Medical Microbiology

7.1	Overview Microscopes	120
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SWIFT available from PHYWE –

Microscopes for all areas of applications

**NEW IN
EUROPE!**

SWIFT has been a globally renowned brand for top-quality microscopes for more than 50 years. Microscopes and stereo microscopes made by SWIFT are designed especially for teaching purposes, which is why they are ideally usable for students, teachers, lecturers, and participants of basic university courses. Their robust design makes them highly durable and perfectly suitable for daily use at schools and universities. Their optical and mechanical quality reflects first-class workmanship and they are particularly easy to use so that even untrained users can quickly produce fascinating images.

In addition to classic microscopes, we offer a series of SWIFT microscopes with integrated digital cameras that ideally meet the requirements of teachers and lecturers. You will surely find the perfect microscope for your individual needs and with an optional price/performance ratio in line with your budget among our new SWIFT microscopes.

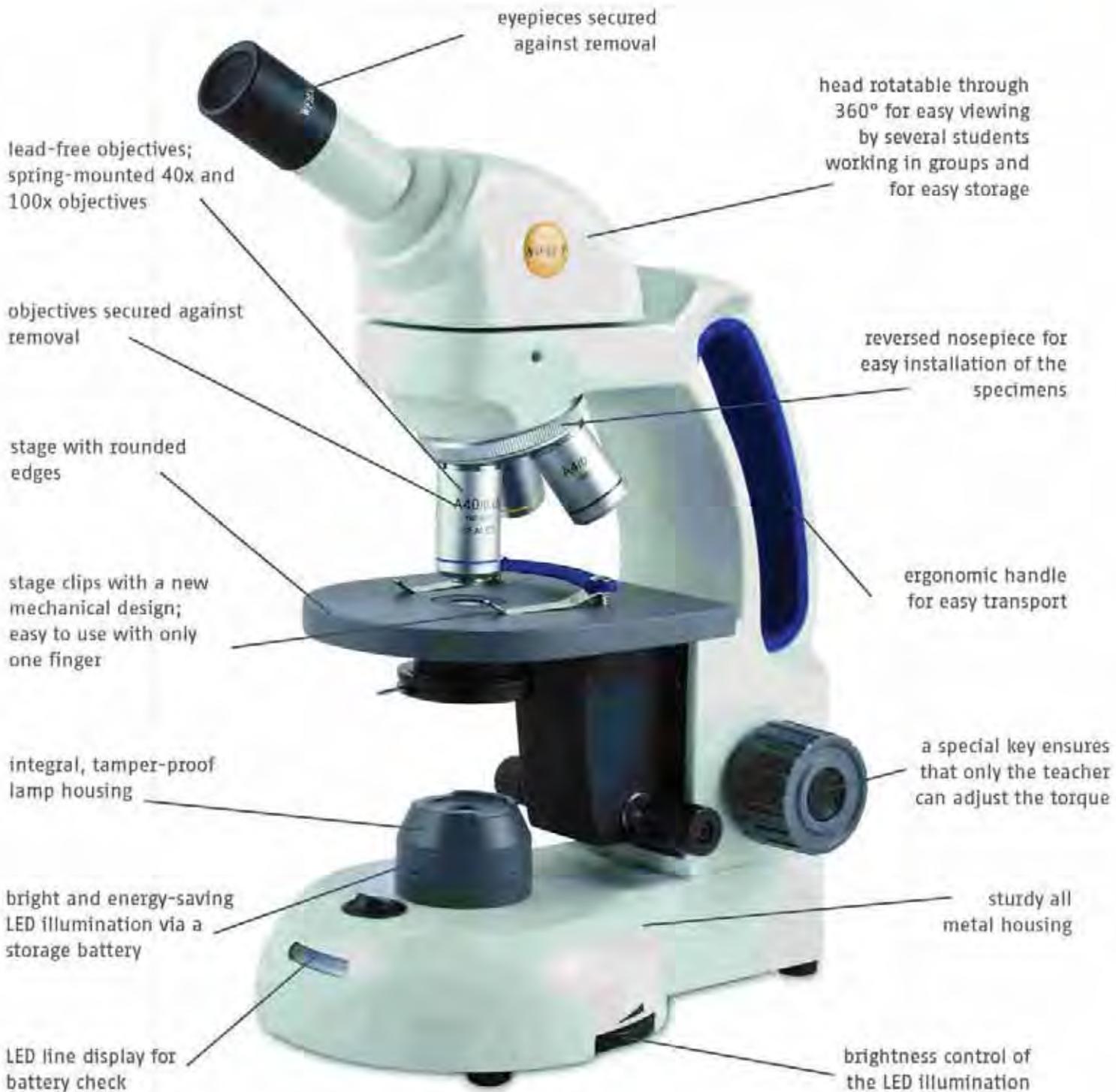
Top features of SWIFT microscopes:

- All-metal design: the all-metal housing and the exclusive use of metal parts inside the microscope ensure a long and trouble-free service life
- Modern, ergonomic design for working without fatigue
- No edges or sharp angles in order to reduce the risk of injury
- Integrated cable holder – trouble-free storage
- Lead-free objectives and eyepieces
- Ergonomic handle for the easy transport of the microscope
- Energy-efficient LED illumination: cold light, low current consumption, and durable
- Variable and controllable illumination for all models; 5 adjustable illumination combinations for stereo microscopes
- Rechargeable LED illumination for mains-power-independent work with battery check via an LED line display
- "Student-proof" student microscopes: objectives and eyepieces secured against removal
- Mechanical and microscope stages with state-of-the-art stage clips: 1-finger-operation





Advantages of the new "student-proof" student microscopes by SWIFT



Microscope Classes –

the right product for every application

Macro-/ Microscopes				
				
SWIFT M3-M monocular Item No. 63001-99	SWIFT M3-B binocular Item No. 63002-99			
Analog Microscopes				
				
MOTIC SFC-100FL Item No. 62417-93	MOTIC SFC-100FL (H) Item No. 62418-93	MOTIC SFC-100F-LED Item No. 62421-93	MOTIC SH Kolleg 3430 Item No. 62223-93	SWIFT M3601C Item No. 63020-99
				
MOTIC 2801-LED monocular Item No. 62195-93	MOTIC 2802-LED monocular Item No. 62196-93	MOTIC 2820-LED binocular Item No. 62197-93	SWIFT M3602C-3 Item No. 63021-99	SWIFT M3702CB-4 Item No. 63022-99
				
SWIFT M10B-5 Item No. 63023-99	SWIFT M10T-5 Item No. 63024-99	MOTIC BA210 Bino LED Item No. 63101-99	MOTIC BA210 Trino LED Item No. 63102-99	MOTIC BA310 Bino LED Item No. 63111-99
				
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MORE THAN MICROSCOPY



Stereo Microscopes



MOTIC ST-30C-2L00, 2x/4x
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SWIFT SM101-C
Item No. 63061-99



SWIFT SM102-C
Item No. 63062-99



SWIFT SM105-C
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MOTIC SMZ-140-N2GG
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Item No. 63205-99

Digital Microscopes



SWIFT M3602C-3DGL
Item No. 63041-99



SWIFT M100B-S
Item No. 63042-99



SWIFT M10LB-S
Item No. 63043-99



MOTIC D-EL1
Item No. 62620-00



MOTIC DS-300 mit USB
Item No. 88037-04

Inverted Microscopes



MOTIC AE2000 Trino
Item No. 63131-99

Cameras



Moticam 15P
Item No. 63301-00



Moticam 3
Item No. 63302-00



Moticam 580
Item No. 63303-99

Nano Imaging

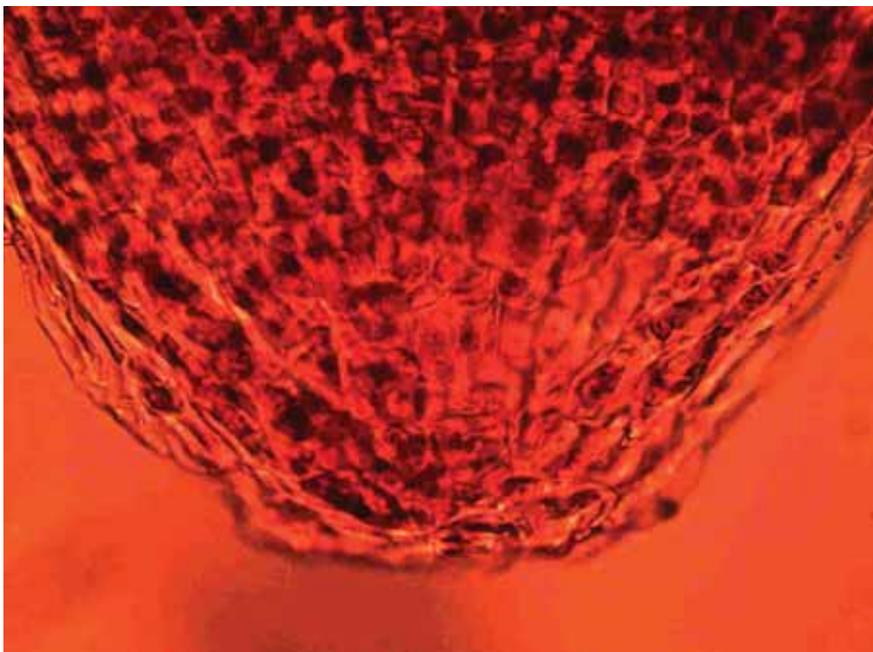


Compact-Scanning Tunneling Microscope (STM)
Item No. 09600-99



Compact-Atomic Force Microscope (AFM)
Item No. 09700-99

P1441401 Nucleus and chromosomes



One drop of carmine acetic acid is pipetted on the slide.

Principle

The nucleus is recognizable under the light microscope as a circular object. It can be seen even without previous staining. The nucleus is the control center of many cellular processes and harbors the hereditary information. The nucleus contains filamentous structures (chromatin) which after staining appear as a homogenous mass. Cell division always commences with a division of the nucleus (mitosis). In preparation to this division, the filaments retract and become shorter and thicker. Staining now makes distinctive objects visible, i.e. the chromosomes. The genetic information they contain has already undergone reduplication. The membrane that envelops the nucleus dissolves, the chromosomes gather in the center of the cell. Attached to the spindle apparatus they migrate to the poles of the cell, where they form two new nuclei. Only then does the body of the cell divide and thus two daughter cells are created.

Tasks

Study plant cells undergoing mitosis under the microscope!

What you can learn about

- Nucleus
- Chromosomes
- Cell division
- Chromatin

Main articles

SWIFT Microscope M3601C	63020-99	1
Chemicals set for TESS Microscopy (for up to 10 workgroups)	13290-10	1
Dropping pipette with bulb, 10 pcs	47131-01	1
Scissors, straight, pointed, l=110mm	64623-00	1
Scalpel holder	64615-00	1

Tweezers, straight, pointed, 120 mm 64607-00 1

Microscopic slides, 50 pcs 64691-00 1

SWIFT Microscope M3601C



Function and Applications

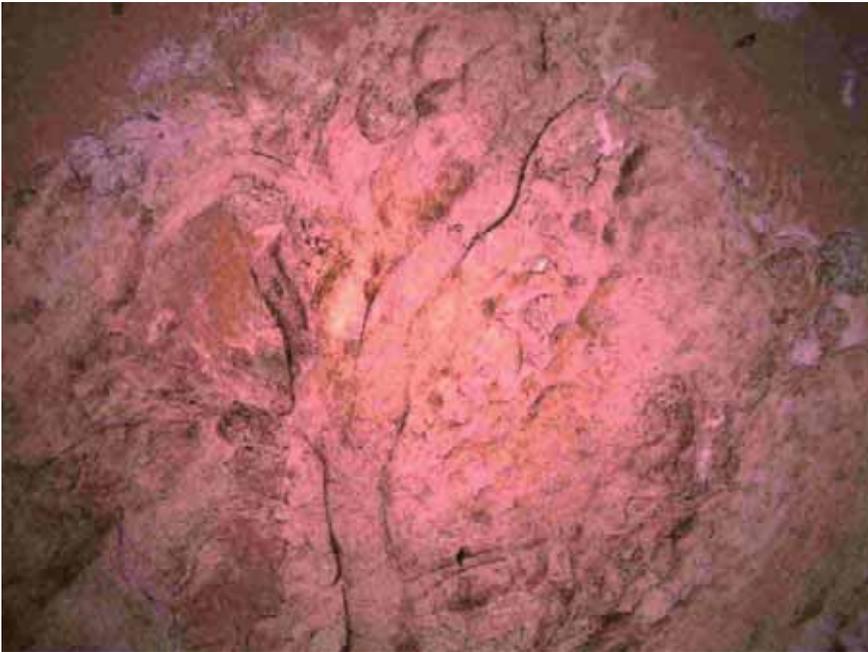
The monocular SWIFT M3601C-3 was developed in particular for using in schools: robust, reliable, long-lasting, durable, against removing protected eyepieces and objectives.

An economical LED-light which is supplied with energy by an accumulator, allows also a working far away from the next mains socket.

63020-99

Kidney

P1443201



Cut a small strip of tissue out of the renal cortex with the scalpel.

Principle

Compared to the liver, the kidney is a rather small organ, however, it is the most significant excretion organ in humans apart from the skin and the lungs. Water and the substances dissolved in it are first transferred to the renal corpuscle (Malpighian body). The liquid travels through delicate tubes, i.e. renal tubes, while a part of the substances is returned to the blood.

Ultimately, the excessive proportion of water, salts, and decomposition products are passed on to the urinary bladder and then excreted.

Tasks

Explore and explain the morphology of the renal corpuscles.

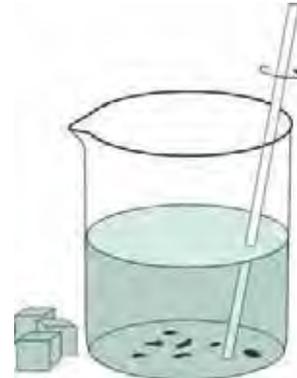
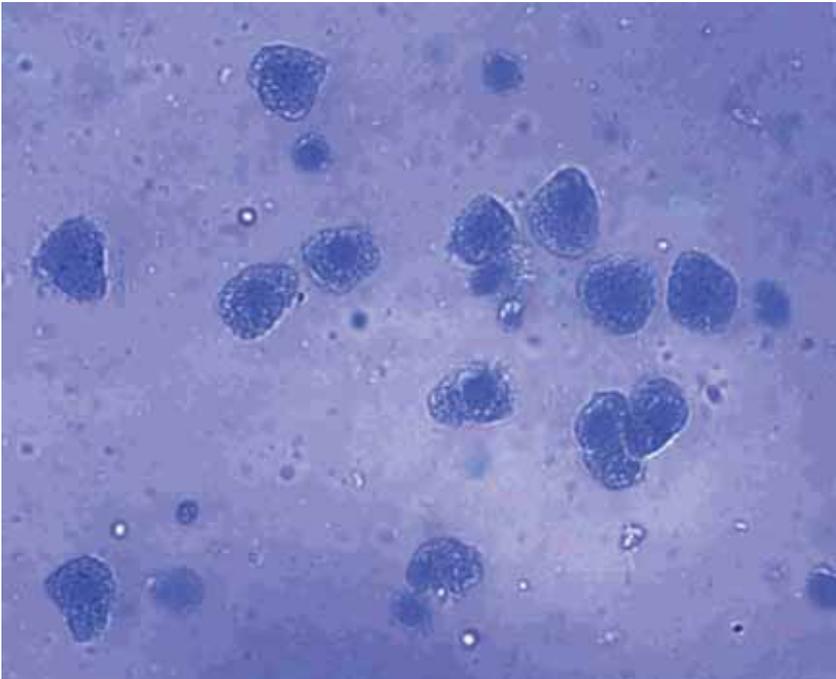
What you can learn about

- Kidney
- Excretion organ
- Renal corpuscle
- Delicate tubes

Main articles

SWIFT Microscope M3601C	63020-99	1
Dropping pipette with bulb, 10 pcs.	47131-01	1
Scalpel holder	64615-00	1
Tweezers, straight, pointed, 120 mm	64607-00	1
Microscopic slides, 50 pcs.	64691-00	1

P1443301 Liver cells (hepatocytes)



The tissue slurry is stirred in the sugar solution.

Principle

The liver is the central organ of human and animal metabolism. It influences, for example, the blood sugar level, synthesizes various blood proteins, and decomposes toxic metabolic products and other toxicants taken up with the food. The bile which the liver produces accumulates in the gallbladder and is discharged into the intestines when needed. It emulsifies dietary fat. The human liver is a very large organ weighing approx. 1,500 g and lies on the right side of the abdomen, directly under the diaphragm.

Tasks

Examine the shape of individual liver cells and compare their structure with a plant cell.

What you can learn about

- Liver
- Liver cells
- Metabolism
- Blood sugar level
- Blood proteins

Main articles

SWIFT Microscope M3601C	63020-99	1
Chemicals set for TESS Microscopy (for up to 10 workgroups)	13290-10	1
Scissors, straight, pointed, l=110mm	64623-00	1
Scalpel holder	64615-00	1
Scalpel blades, rounded tip, 10 off	64615-02	1
Tweezers, straight, pointed, 120 mm	64607-00	1
Microscopic slides, 50 pcs	64691-00	1

Related Experiment

Blood cells

P1443101

P5911900

Analysis of Urinary Sediment



For more details refer to page 105.

Principle

The analysis of urinary sediment is an in-depth analysis in case of a pathological test strip finding showing positive test results for leucocytes, erythrocytes, protein, nitrite or a pH>7. Erythrocytes, epithelia, cylinders, bacteria, trichomonads, fungi and crystals are detected and identified with the aid of a microscope.

P5921300

Erythrocyte Count



For more details refer to page 109.

Principle

In this experiment, erythrocytes are counted manually in a counting chamber under the microscope.

P5921500

Differential Blood Count



For more details refer to page 110.

Principle

In manual blood counts, a droplet of blood is spread on a slide in such a manner that the cells are located separately, side by side in one layer. After application of the Pappenheim's stain, the cells can be classified individually by size, nucleus-plasma relation, shape and structure of nucleus, colour and granulation of cytoplasm. The erythrocytes will be assessed as well.

P4140300 Microscopy of bacteria



The bacteria are placed on the microscope slide.

Principle

The microscopic examination of microorganisms can be performed based on live specimens or in fixed and stained preparations. Live specimens of microorganisms are prepared in a drop of water (or culture liquid). The aim of staining bacteria preparations is to increase the contrast between the bacteria and their environment from which they hardly stand out when unstained.

Tasks

Examine a bacteria preparation under a microscope and apply the standard methods that are described herein.

What you can learn about

- Bacteria
- Sterility
- Microscope
- Staining

Main articles

SWIFT Microscope M3601C	63020-99	1
Ethyl alcohol, absolute 500 ml	30008-50	1
Entellan, quick-embedding, 100 ml	31294-10	1
Bunsen burner, natural gas, w.cock	32167-05	1
Methylene-blue B, for microscopy, 25 g	31567-04	1
Wire loop, streaking	64936-00	1
Carbol-fuchsine solution 100 ml	31463-10	1

Related Experiment

Bacteria

P1444901

SWIFT Microscope M3601C



Function and Applications

The monocular SWIFT M3601C-3 was developed in particular for using in schools: robust, reliable, long-lasting, durable, against removing protected eyepieces and objectives. An economical LED-light which is supplied with energy by an accumulator, allows also a working far away from the next mains socket.

63020-99

P1443801
Nematoda



Principle

Threadworms (nematodes) are whitish or colorless roundworms of very simple organization, which occur almost everywhere in moist soils, in water, and also as parasites in plants, animals and humans.

For more details refer to www.phywe.com

P5921800
Malaria



Principle

Malaria is caused by plasmodia. The disease is transmitted via the female form of the anopheles mosquito. Plasmodium falciparum is the pathogenic agent of the tropical disease malaria tropica, which is the most dangerous form of malaria. The thick drop method is applied to diagnose not only malaria but also other parasitic diseases such as sleeping sickness. Various forms of the pathogenic agent and typical signs such as Maurer's spots and Schüffner's dots are easier to detect in a complementary differential blood count.

For more details refer to page 113.

P1444301
Mould fungi growing on food

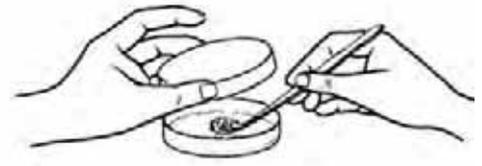


Principle

Surely you have seen on several occasions that molds have grown on food. Molds live on organic matter composed of carbohydrates, fat, and protein. As foodstuffs contain these substances and the required moisture, they make an ideal substrate. The macroscopically visible mold constitutes but one part of the fungus. It only emerges when the food is fully interspersed with mycelial threads (hyphae). As many molds produce toxic substances, moldy foodstuffs should not be consumed.

For more details refer to www.phywe.com

P4140200 Evidence of the spread of bacteria



Contamination of the agar plate.

Principle

Microorganisms are ubiquitous, i.e. they are present everywhere around us. This fact can be proved by touching the objects that are to be examined in view of the presence of microorganisms against the sterile nutrient medium in a Petri dish and by incubating the plates afterwards. The easy working methods that are to be applied for this purpose are described based on the following examples. Evidence concerning the presence of microorganisms in soil and water can be provided most easily with the aid of the methods that are described in section 4. They also enable a quantitative analysis.

Tasks

1. Provide evidence concerning the presence of microorganisms in the air.
2. Provide evidence concerning the presence of microorganisms on objects of daily use.
3. Provide evidence concerning the presence of microorganisms on the skin.
4. Provide evidence concerning the presence of microorganisms on insects.

What you can learn about

- Disinfection
- Nutrient agar
- Sterility

Main articles

Autoclave with insert	04431-93	1
Drying oven UNB200, timer, 32 l	46959-93	1
Compact Balance, OHAUS TA 302, 300 g / 0.01g	49241-93	1

Heating + cooking hotplate, 230 V	04025-93	1
Ethyl alcohol, absolute 500 ml	30008-50	1
Bunsen burner, natural gas, w. cock	32167-05	1

Related Experiment

Fundamental microbiological working methods

P4140100

Autoclave with insert

Function and Applications

Portable autoclave.

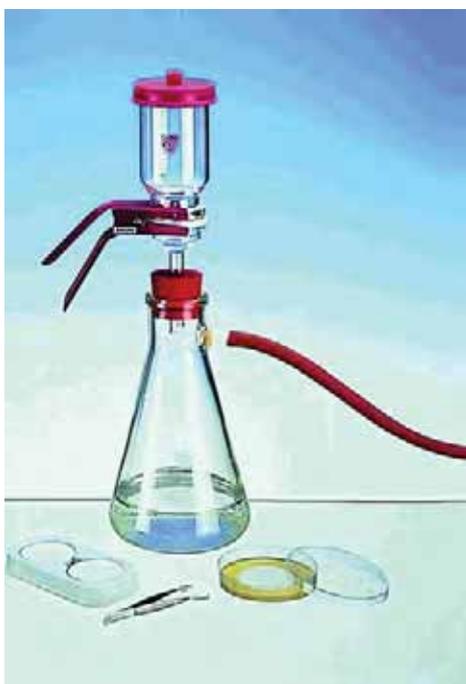
Equipment and technical data

- Precision manometer
- Thermometer
- Integrated heating
- Application range up to 1.4 bar at 125°C or up to 2.7 bar at 140°C
- Volume: 12 liters; Safety valve
- Excess pressure safetyvalve
- Safety lock

04431-93

Determination of the microbial count

P4140400



Principle

The microbial count is the number of viable microorganisms in one millilitre or gramme of the material to be examined, e.g. water, soil, milk, ice cream, etc. It is of high practical importance for the analysis of drinking water, soil, and foodstuffs. The microbial count can only be determined exactly if all of the related tasks are performed in a way that prevents the material that is to be examined from being contaminated with foreign microorganisms.

Tasks

Determine the microbial count of the sample.

What you can learn about

- Microbial count
- Microorganisms
- Analysis of drinking water

Main articles

Autoclave with insert	04431-93	1
Drying oven UNB200, timer, 32 l	46959-93	1
SWIFT Microscope M3601C	63020-99	1
Compact Balance, OHAUS TA 302, 300g/0.01g	49241-93	1
Diaphragm filter apparatus	64906-00	1
Diaphragm filters, pkg. of 100 pcs.	64907-00	1
Heating + cooking hotplate, 230 V	04025-93	1
Ethyl alcohol, absolute 500 ml	30008-50	1
Agar-agar, powdered 100 g	31083-10	1
Filter flask, 1000 ml, PN 45	34421-01	1



Flame treatment of spatula.

Diaphragm filter apparatus



Function and Applications

Diaphragm filter apparatus for determining the number of bacteria in water and soil samples, for harvesting organisms from cell suspensions and for sterile filtration of solutions.

64906-00

P4140500 Evidence of the effect of antibiotics, chemotherapeutics and disinfectants



Deposition of disinfectant.

Principle

Evidence concerning the effect of substances inhibiting the growth of microorganisms, e.g. antibiotics, chemotherapeutics, and disinfectants, can be provided by treating cultures with the substances to be studied and by observing the growth of the microorganisms. Evidence concerning the effect of disinfectants can be provided by letting sterile agar in Petri dishes become infected with airborne microorganisms, spraying the plates with the disinfectant to be studied, and by incubating the plates. This method can also be applied in order to demonstrate and compare the effect of different concentrations of the same disinfectant in a manner that is usually sufficient for school purposes. Evidence concerning the effect of antibiotics and chemotherapeutics can be provided by way of the so-called punched-hole test.

Tasks

1. Evidence of the effect of antibiotics and chemotherapeutics.
2. Evidence of the effect of disinfectants.

What you can learn about

- Disinfection
- Nutrient agar
- Sterility

Main articles

Autoclave with insert	04431-93	1
Drying oven UNB200, timer, 32 l	46959-93	1
Compact Balance, OHAUS TA 302, 300 g / 0.01 g	49241-93	1
Agar-agar, powdered 100 g	31083-10	1
Autoclavable disposable bag, PA	46428-04	1

Bunsen burner, natural gas, w.cock	32167-05	1
Peptone, dry, from meat 50 g	31708-05	1
Water, distilled 5 l	31246-81	1
pH test sticks 6.5-10, 100 sticks	30301-04	1
Sterile stoppers f. id 29 mm, 100	39267-00	1

Drying oven UNB200, timer, 32 l



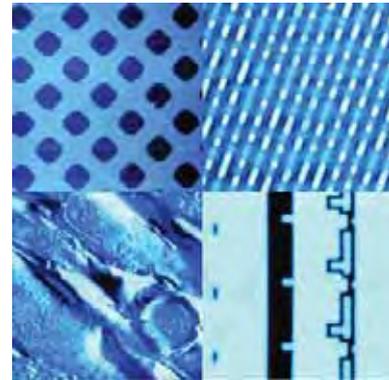
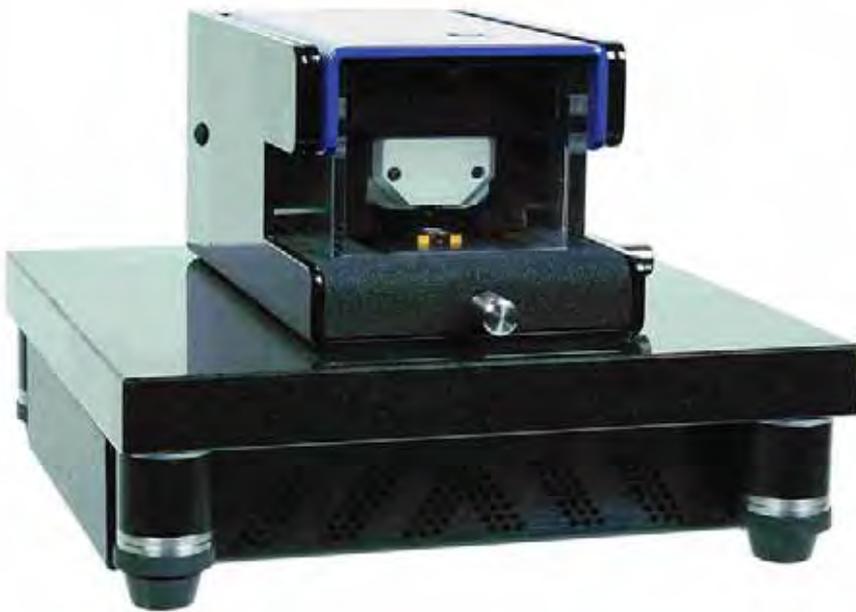
Function and Applications

Drying oven UNB200 for drying, sterilizing, warming and incubating in the temperature range from 30 °C to 220 °C.

46959-93

Basic methods in imaging of micro and nanostructures with atomic force microscopy (AFM)

P2538000



Topography of Microstructure (50 micrometer), CD Stamper (20 micrometer), Skin Cross-Section (60 micrometer), and SCA chip structure (40 micrometer) FLTR.

Principle

Approaching a sharp silicon tip mounted on a cantilever to a sample surface leads to an atomic scale interaction. The results is a bend of the cantilever which is detected by a Laser. In static mode the resulting deflection is used to investigate the topography of the sample surface line-by-line using a feedback loop. In dynamic mode the cantilever is oscillated at fixed frequency resulting in a damped amplitude near the surface. The measurement parameters (setpoint, feedback gain,...) play a crucial role for image quality. The dependence on the imaging quality is investigated for different nano structured samples.

Tasks

1. Set-up the microscope and start up the software. Mount a cantilever (with tip) and approach the tip towards a sample.
2. Investigate the influence of the scanning parameters on the imaging quality and performance, e.g. PID gain, setpoint (force), vibrational amplitude, and scanning speed. Use both static and dynamic force mode.
3. Image 7 different samples (microstructures, carbon nano tubes, skin cross-section, bacteria, CD stamper, chip structure, glass beads) by optimizing the parameters respectively.

What you can learn about

- Atomic Force Microscopy (AFM)
- Lennard-Jones potential
- Imaging of nano structures
- Static Force Mode
- Dynamic Force Mode
- Feedback Loop
- Force
- Vibrational Amplitude

Main articles

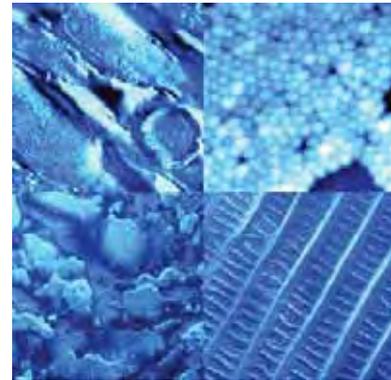
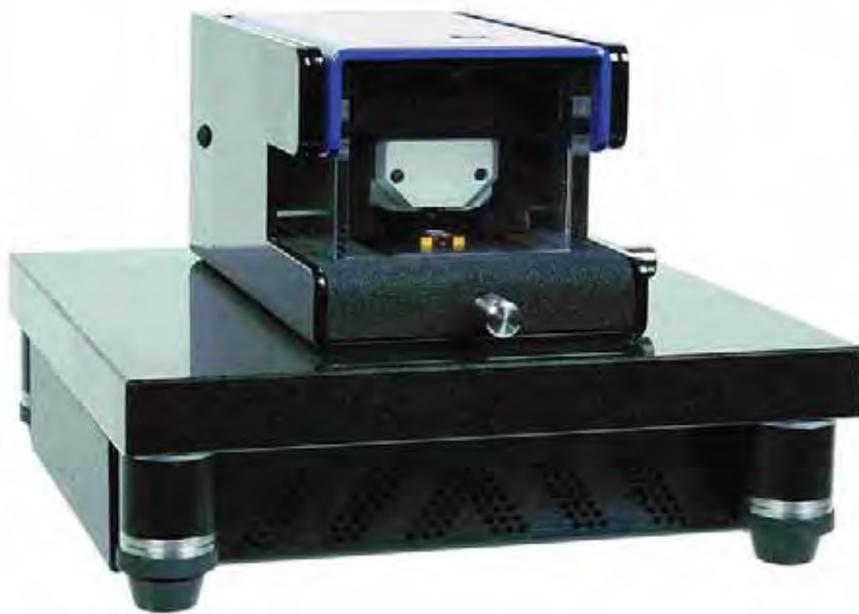
Compact-Atomic Force Microscope (AFM)	09700-99	1
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Training recommended **Service** | PHYWE

For this experiment we recommend a seminar on equipment technology, handling and information of equipment-specific characteristics on site.

03333-02

P2538400 Imaging of biological and medical micro and nanostructure with atomic force microscopy (AFM)



Topography of Skin Cross-Section (60 micrometer), Staphylococcus Bacteria (10 micrometer), Human hair (40 micrometer), and Butterfly Wing (10 micrometer) FLTR.

Principle

Dynamic Atomic Force Microscopy is used to image and visualize several biological samples at a sub micrometer scale. A collection of both pre-prepared and freshly prepared samples are investigated, e.g. bacteria, skin cross-section, human hair, butterfly wing, blood cells, and fly eye. With high resolution imaging the relation between small biological structures and their function can be identified and different treatments could be recognized at this scale. One example is the imaging of different skin layers showing dead and living epithelial layer, collagen layer, hair follicle and structures within it. Another example is the imaging of different regular lattice structures to clarify the colour effect of butterfly wings

Tasks

1. Set-up the microscope and start up the software. Mount a cantilever and approach the tip towards a sample.
2. Use pre-prepared samples and investigate their topography by optimizing the imaging parameters. Discuss the relation between the imaged structures with their function.

- Skin cross-section: different layers and their structures
- Staphylococcus Bacteria: form, alignment and surface structure

3. Prepare different samples and investigate their topography by optimizing the imaging parameters. Discuss the relation between the imaged structures with their function and treatment.

- Blood cells: different form and structure, function
- Butterfly wing: different regular structures, interference of light and colour effect

- Fly eye: compound of many "eye" units, resolution, viewing angle, reaction time
- Human hair: treatment dependence of surface structure (coloured and non-coloured, wet and dry)

What you can learn about

- Atomic Force Microscopy
- Dynamic mode, Feedback loop
- High resolution 3D imaging
- Nano Imaging of biological and medical samples
- Relation of structure and function
- Blood Cells; Butterfly Wing; Insect Eye
- Bacteria; Skin; Human hair

Main articles

Compact-Atomic Force Microscope (AFM)	09700-99	1
Sample support, 10 pcs, for Compact Scanning Tunneling Microscope and Atomic Force Microscope	09619-00	1
Cover glasses 18x18 mm, 50 pcs.	64685-00	1

Training recommended **Service** | PHYWE

For this experiment we recommend a seminar on equipment technology, handling and information of equipment-specific characteristics on site.

03333-02

Compact-Atomic Force Microscope (AFM)



Function and Applications

Compact and easy to use atomic force microscope to visualize and image structures on the micro and nano meter scale. Developed for educational purposes in practical lab course and pre-research labs in physics, chemistry, life sciences and material sciences. Also suitable to determine material characteristics (e.g. stiffness, magnetization, charging, material and phase contrast) and for manipulation (e.g. lithography).

Benefits

- Out-of-the-box device with integrated damping plate and control unit underneath
- Complete set, incl. Sample Set, Cantilever, Tools and Consumables
- Tip Scanner AFM for standard cantilever
- Easy and safe cantilever exchange and use: Flip mechanism with automatic laser switch off
- no laser alignment, mechanical stopper for longer lifetime of cantilevers
- Digital top view camera for easy positioning and side view lens for easy and fast approach
- Portable and compact: transportable, easy to install with a small footprint
- Easy to use: Ideal for nanotechnology education, preparing students for their work on high-level research devices, and outreach

Equipment and technical Data

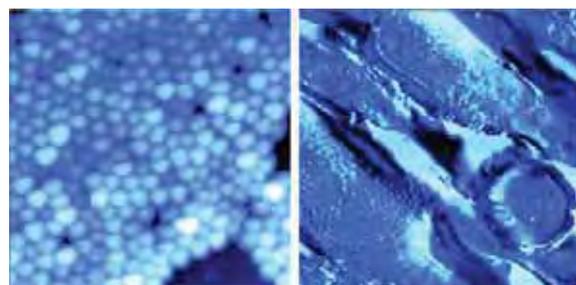
- Scan head with integrated control-unit on vibration-isolated experimentation board: 21cm x 21cm x 18cm, USB 2.0 interface, 16 bit DA converter (XYZ), 16 bit AD converter (7 channels)
- Max scanning speed 60 ms/line, up to 2048x2048 data points
- Scan type (tip scanner): Linear low voltage electro magnetic
- Scan Range: 70 micro meter (1.1 nm resolution)
- Z-range: 14 micro meter (1.1 nm resolution); Z noise level (RMS): 0.6 / 0.5 nm (static / dynamic); Automatic approach: vertical, range 4.5 mm
- Sample: max. 13 mm in diameter, horizontal mount, LED illumination, Micrometer translation stage xy: min. +/- 5 mm
- Cantilever Alignment: automatic adjustment, alignment grooves from various suppliers; Camera system for top view: USB digital color, 3.1 M pixels
- Modes of operation: Static Force, Dynamic Force, Force Distance Spectroscopy, Amplitude Distance Spectroscopy

- Other modes (MFM,AFM, Phase contrast, lithography and advanced spectroscopy modes)
- available with upgrade options material and spectroscopy and manipulation
- User expandability (scripting) available (upgrade option); Set of 10 Cantilever, 6 samples, Toolset
- Software for measuring, manipulation, analysing and visualization, Handbook and Quick Installation Guide

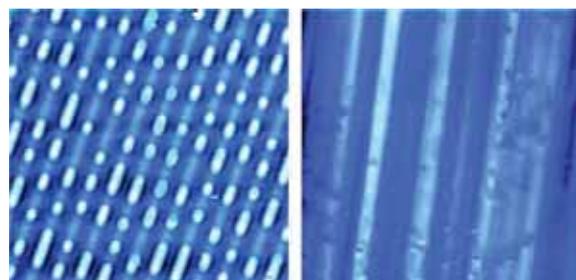
Accessories

- Material upgrade (Art. 09701-00): Additional Operating Modes (Phase Contrast, EFM, MFM, Force Modulation, Spreading Resistance), set of samples and cantilevers
- Spectroscopy and Manipulation upgrade (Art. 09702-00): Additional Operating Modes (Advanced Spectroscopy, Lithography (scratching, oxidation), Manipulation (oxidation, cutting and moving/pushing of nanoparticles)), User expandability (Visual basic, LabView, etc.), set of cantilevers and samples
- Side View Camera System (available 2013), other samples

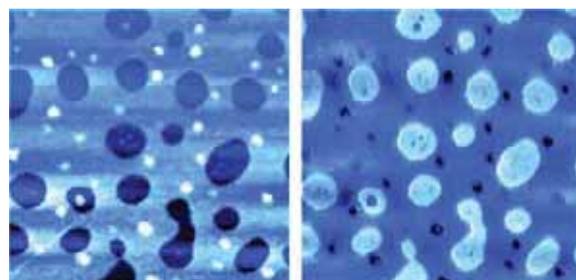
09700-99



Staphylococcus Spec., 10 µm and Skin Cross-Section, 60 µm

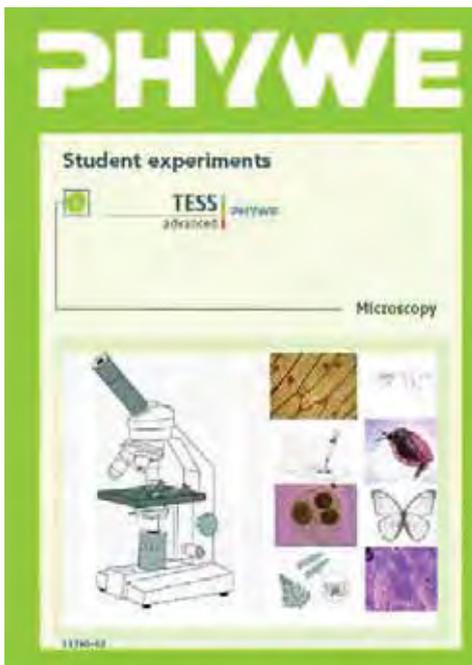


CD Stamper, 20 µm and Aluminum Foil, 60 µm



PS/PMMA films: Topography and Phase Contrast, 3 µm

TESS advanced Biology manual Microscopy



Article no. 13290-02

Description

Experimental literature for 50 experiments with:

1. Student worksheets with black/white drawings for easy copying and Teacher's sheets with colored digital microscopy images.
2. CD-ROM with master copies of: color presentation files (PDF format) for 47 microscopy topics to print transparencies or to show directly via a video beamer and PDF files of student worksheets and teacher's sheets.

Topics

- Basics of microscopy
- Worktechniques
- Cell components
- Seed plants and ferns
- Vertibrates and invertebrates
- Fungi
- Protists
- Prokaryotes

Equipment and technical data

200 pages

This documentation contains the following experiments:

The components of a microscope MI 1.1

P1440001

Working with the microscope

P1440101

Microscopic magnification

P1440201

Preparation of temporary microscopic slides

P1440301

Manual section technique

P1440401

Staining of living organisms

P1440501

Rapid staining technique

P1440601

Fixation and staining

P1440701

Embedding in Canada balsam

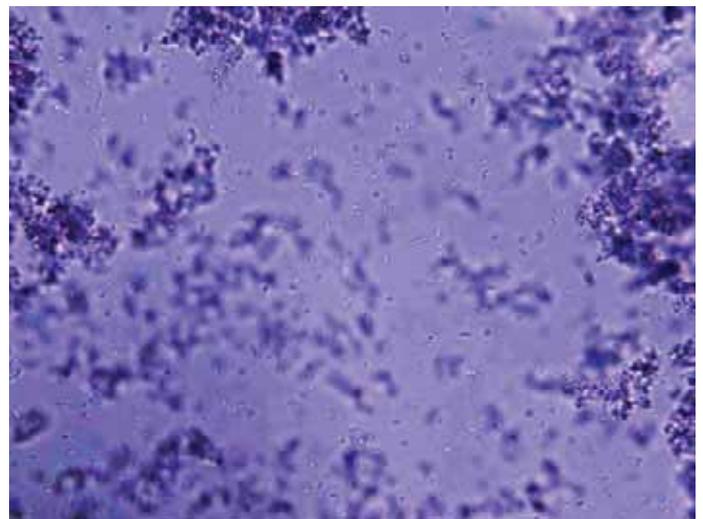
P1440801

Preparation of reagents

P1440901

Complete experiment list see www.phywe.com

13290-02



P1444901 - Bacteria



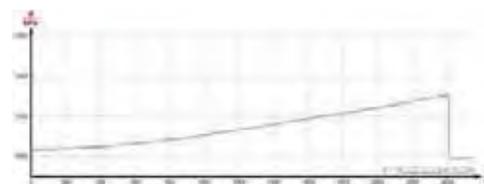
P1444501 - Colony-forming ciliates in an aquarium



Biochemistry

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P4110460 Glycolysis (pressure measurement) (with Cobra4)



Measurement of carbon dioxide pressure versus time result at room temperature.

Principle

The aim of this experiment is to prove glycolysis by means of measuring the CO_2 production under various experimental conditions (temperature, pH).

Tasks

1. To identify glycolysis by measuring the production of CO_2 and plotting graphs.
2. To investigate the influence of temperature and pH on metabolic activity.

What you can learn about

- Glycolysis
- Yeast fermentation of sugar
- CO_2 pressure measurement
- Influence of temperature and pH

Main articles

Software Cobra4 - multi-user licence	14550-61	1
Cobra4 Sensor-Unit Thermodynamics, pressure abs. 2 bar and 2 temperature NiCr-Ni	12638-00	1
Cobra4 Wireless-Link	12601-00	1
Cobra4 Wireless Manager	12600-00	1
Magnetic stirrer Mini / MST	47334-93	1
Holder for Cobra4 with support rod	12680-00	1
Support base variable	02001-00	1
Universal clamp with joint	37716-00	1
Bunsen burner DIN, nat. gas	32165-05	1
Buffer solution tablets pH4, 100	30281-10	1

Related Experiment

Glycolysis (temperature measurement) (with Cobra4)

P4110560

Cobra4 Sensor-Unit Thermodynamics, pressure abs. 2 bar and 2 temperature NiCr-Ni



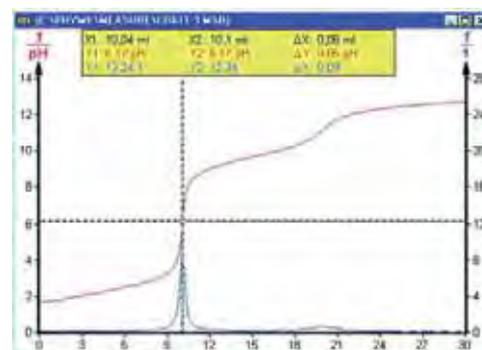
Function and Applications

The Cobra4 Sensor-Unit Thermodynamics is a measuring recorder for pressure and temperature measurements, which is controlled by micro-controller.

12638-00

Determination of the isoelectric point of an amino acid (glycine) (with Cobra3)

P4120140



Titration curve for hydrochloric acid glycine solution against 1 mol/l NaOH.

Principle

Amino acid molecules carry both acid and amino groups. They can therefore form both acidic anions and basic cations. The pH at which these two types of ions are both present in the same concentration is called the isoelectric point.

Tasks

This isoelectric point is to be determined by recording the titration curve for the amino acid glycine.

What you can learn about

- Isoelectric point
- Acidic anions
- Basic cations
- Zwitterions
- Equivalence (inflection) points
- pI value
- Titration
- Motor piston burette

Main articles

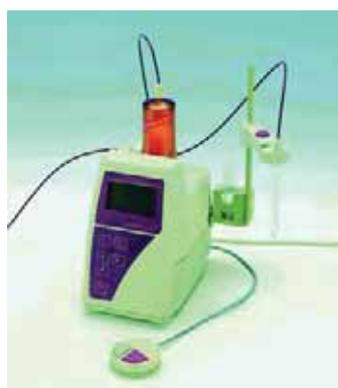
Motor. piston burette, univer., 50ml	36499-93	1
Cobra3 Chem-Unit, USB	12153-50	1
Software Cobra3 Chem-Unit	14520-61	1
Immers. probe NiCr-Ni, teflon, 200°C	13615-05	1
Magnetic stirrer Mini / MST	47334-93	1
pH-electrode, plastic body, gel, BNC	46265-15	1
Cable Chem-Unit/Motor piston burette	36501-01	1
Power supply 12V / 2A	12151-99	1
Caustic soda sol., 1.0M 1000 ml	48329-70	1
Hydrochloric acid, 1.0 mol/l, 1000 ml	48454-70	1

Cobra4 Experiment - available 2013

Determination of the isoelectric point of an amino acid (glycine) (with Cobra4)

P4120160

Motor. piston burette, univer., 50ml

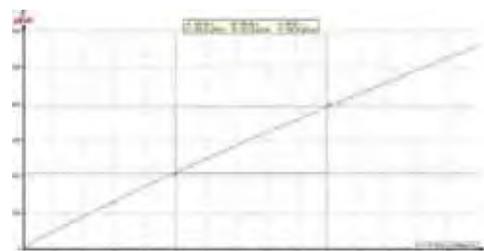


Function and Application

For uniform portioning and reproducible titrations. Microprocessor controlled, with remote control.

36499-93

P4120360 Determination of the Michaelis constant (with Cobra4)



Conductivity-time-diagram of the urea hydrolysis by urease.

Principle

The enzymatic hydrolysis of urea in aqueous solution liberates carbon dioxide and ammonia. The ions of these compounds increase the conductivity of the solution. Conductivity measurements can so be made to determine the rate of hydrolysis of urea by the enzyme urease at various substrate concentrations.

Tasks

The Michaelis constant can then be calculated from these values.

What you can learn about

- Michaelis constant
- Enzymatic hydrolysis of urea
- Conductivity measurement
- Bodenstein principle
- Enzyme-substrate complex
- Lineweaver-Burk plot

Main articles

Software Cobra4 - multi-user licence	14550-61	1
Cobra4 Sensor-Unit Conductivity+, Conductivity/ Temperature (Pt1000)	12632-00	1
Cobra4 USB-Link	12610-00	1
Conductivity Temperature probe Pt1000	13701-01	1
Urease soln. in 50% glycerol, 10ml	31924-03	1
Magnetic stirrer Mini / MST	47334-93	1
Micro-l syringe, 100 micro-l	02606-00	1
Urea, 250 g	30086-25	1

Cobra4 Sensor-Unit Conductivity+, Conductivity/ Temperature (Pt1000)



Function and Applications

The Cobra4 Sensor Unit Conductivity/Temperature (Pt1000) is a microcontroller-based measuring recorder with a 5-pin diode socket for connecting conductance measuring sensors with a cell constant of $K = 1.00/\text{cm}$ or Pt1000 thermocouples.

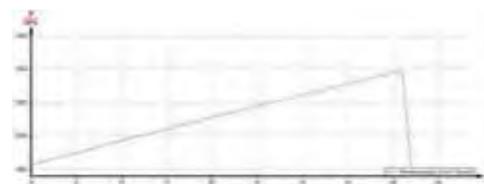
Benefits

The Cobra4 sensor may be connected directly to the Cobra4 Wireless-Link unit, the Cobra4 Mobile-Link unit or the Cobra4 USB-Link unit using a secure and reliable snap-in connection.

12632-00

The enzymatic activity of catalase (with Cobra4)

P4120660



Measurement result under normal conditions.

Principle

Determination of the enzymatic activity of catalase.

Tasks

1. Examine the enzymatic decomposition of hydrogen peroxide, a cell respiratory poison, in the liver.
2. Investigate the influence of temperature and pH on the metabolic activity.

What you can learn about

- Enzyme catalase
- Decomposition of H_2O_2
- Poisonous by-product of cell respiration
- Influence of temperature and pH

Main articles

Software Cobra4 - multi-user licence	14550-61	1
Cobra4 Sensor-Unit Thermodynamics	12638-00	1
Cobra4 USB-Link	12610-00	1
Magnetic stirrer Mini / MST	47334-93	1
Holder for Cobra4 with support rod	12680-00	1
Support base variable	02001-00	1
Caustic soda sol., 1.0M 1000 ml	48329-70	1
Hydrochloric acid, 1.0 mol/l, 1000 ml	48454-70	1

Related Experiments

Substrate inhibition of enzymes

P4120460

Enzyme inhibition (poisoning of enzymes) with Cobra4

P4120560

Cobra4 USB-Link

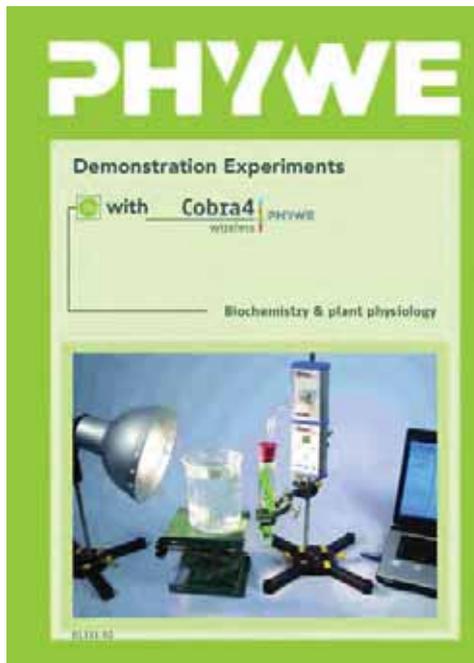


Function and Applications

The Cobra4 USB-Link is a highly efficient interface module for the transmission of sensor measuring values to a PC via a USB connection.

12610-00

Demo advanced Biology Manual Cobra4 Biochemistry & plant physiology



Article no. 01331-02

Description

Experimental descriptions from the fields of biochemistry and plant physiology that pay particular attention to the advantages of data acquisition with the Cobra4 System. In total more 10 demonstration experiments are described in detail.

Topics

- Photosynthesis (2 different methods)
- Transpiration of leaves
- Glycolysis (2 different methods)
- The ionic permeability of the cell membrane
- Determination of the Michaelis constant
- Enzyme inhibition
- Substrate inhibition of enzymes
- The enzymatic activity of catalase

Equipment and technical data

Din A4 stapled; in colour, 56 pages

This documentation contains the following experiments:

Transpiration of leaves

P1351260

Photosynthesis (O₂ pressure measurement) (with Cobra4)

P1351360

Glycolysis (temperature measurement)

P1351460

The enzymatic activity of catalase

P1360760

Photosynthesis (bubble-counting-method)

P1360860

Glycolysis (pressure measurement)

P1360960

Ionic permeability of the cell membrane
P1369760

Determination of the Michaelis constant
P1369860

Substrate inhibition of enzymes
P1369960

Enzyme inhibition (poisoning of enzymes)
P1370060

01331-02



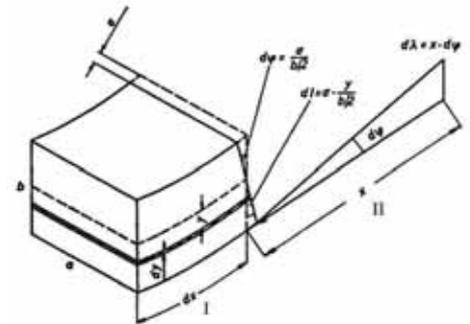
P4120660 - The enzymatic activity of catalase.



Biomechanics

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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 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 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

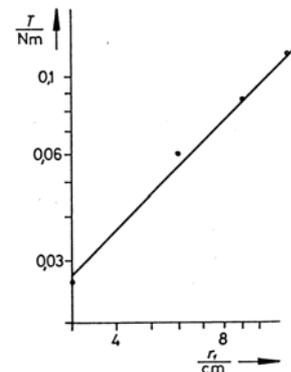
Main articles

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



Moments

P2120100



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
Right angle clamp PHYWE	02040-55	1
Boshead, turnable	02048-04	1

Related Experiment

Mechanical hysteresis

P2120300

Cobra4 Sensor-Unit Force ± 40 N



Function and Applications

The Cobra4 Sensor-Unit Force ± 40 N contains a bending beam (DMS technology), which converts the mechanical load into an electrical signal.

12643-00

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 PC at the campus and on all personal PCs of the students and teachers belonging to the campus!

Benefits

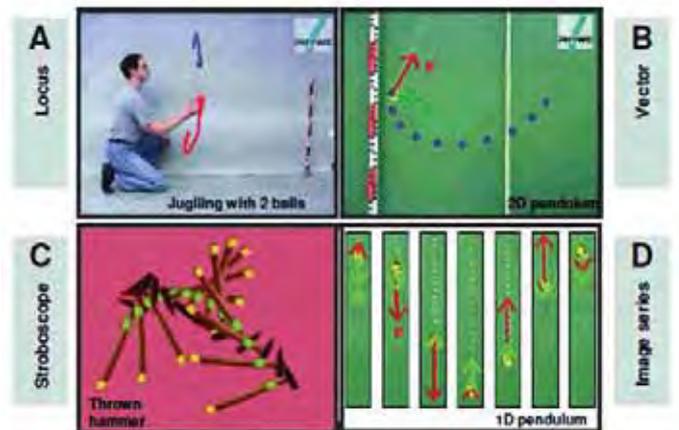
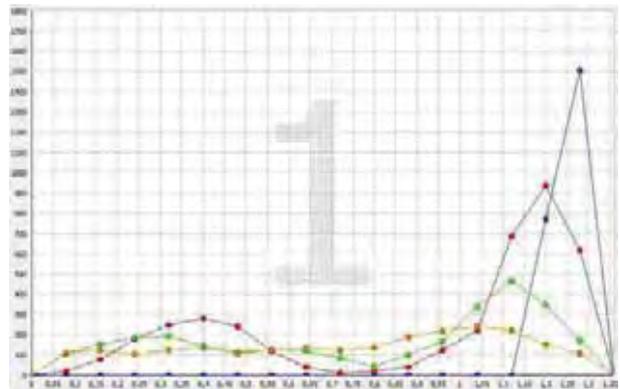
- Automatic object recognition and tracing, including several filmed objects simultaneously, e.g. coupled pendulum
- Dialogue-supported creation of trajectories as well as movement, velocity and acceleration diagrams
- Stroboscopic effect for motion sequences (visualization of the entire path of movement)
- 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

EduMedia Award for Didactical Software



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

P1199560**Impulse and momentum / demonstration track with Cobra4****Principle**

An impulse is described as the change in momentum by a force applied upon a body for a small interval of time. The momentum is defined here as the product of force and time and is conserved if no friction loss occurs. This means that in a closed system of different bodies the latter can transfer or receive momentum, however the total momentum of the system remains temporally and quantitatively constant.

For more details refer to www.phywe.com

12650-00**Cobra4 Sensor-Unit 3D-Acceleration, $\pm 2\text{ g}$, $\pm 6\text{ g}$** **Function and Applications**

Depending on application type, the Cobra4 Sensor-Unit 3D-Acceleration, $\pm 2\text{ g}$, $\pm 6\text{ g}$ can be connected to the Cobra4 Wireless-Link, the Cobra4 Mobile-Link or the Cobra4 USB-Link using a secure and reliable plug-in / lockable connection.

Benefits

- Specifically with this sensor, the use of Cobra4 Wireless enables completely new experimentation possibilities.
- As such, it is possible to investigate e.g. the acceleration of the sensor in freefall or the acceleration of a schoolchild on a bicycle etc..

For more details refer to www.phywe.com

12620-55**Cobra4 Mobile-Link set, incl. SD memory card, USB cable and software "measure"****Function and Applications**

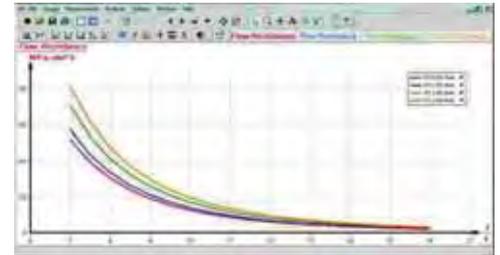
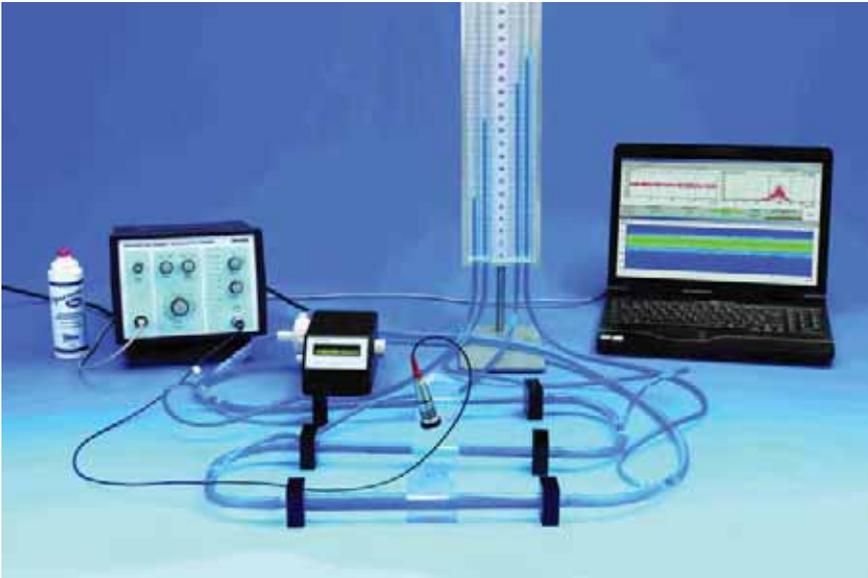
The Cobra4 Mobile-Link is a modern, high performance hand measuring device for mobile data recording, to which all Cobra4 Sensor-Units can be connected via secure plug-in/ lockable connection.

Benefits

- Up to 1,000 measuring values/sec
- Data can be saved on an SD memory card
- Automatic detection of all Cobra4 Sensor-Units
- Foolproof navigation with central navigation cross
- "measure" evaluation software can be used for FREE
- Water-resistant and reliable for outdoor work

For more details refer to www.phywe.com

P5140100 Mechanics of flow



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 great many 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 Experiments

Flow Measurement / Ultrasonic Doppler effect

P5142100

Doppler sonography

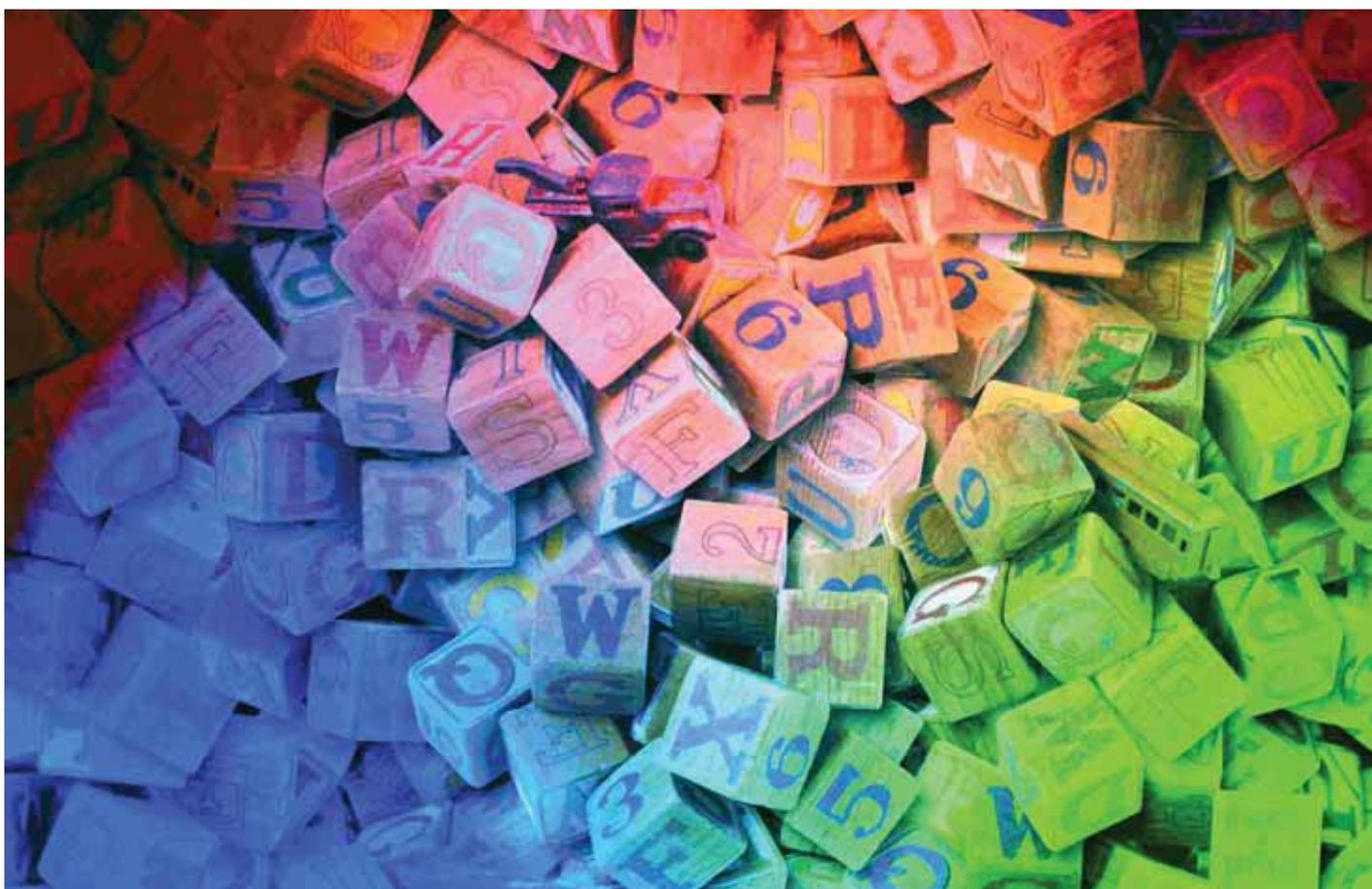
P5950100

Extension Set: Mechanics of flow

Function and Applications

With this set the Doppler effect as well as basic flow phenomena can be demonstrated. A flow circuit can be built up, containing various tube diameters and therefore with different flow velocities. With the Doppler prisms, the relationship between Doppler frequency shifts, the angle of incidence, the transmission frequency and flow velocity can be determined. Within the flow profile, laminar or turbulent flow can be measured. The stand pipes indicate the pressure measured at different points in the circuit. With data of pressure, tube diameter and flow velocity fundamental laws of laminar flow, like the Bernoulli equation and the Hagen-Poiseuille law, can be studied.

13923-01



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10 Indices

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General notes on safety

Notes on safety

The regulations for dealing with electrical devices, lasers, radioactive materials and hazardous materials are not uniform worldwide. Before any experimentation, it is essential that you become familiar with the national and local laws, directives and ordinances regarding the handling of the-

se appliances and materials, as well as their storage and transport.

You can refer as an example to our notes on safety, which correspond to the high German and EU standards. The laws in the respective country are binding, however.

1.) Experiments using electrical energy

The utilisation of the electrically operated devices (mains power supply) that are offered herein is only allowed in science rooms of educational institutions, schools, universities, and laboratories, but NOT in residential areas.

Experiments at school usually use non-hazardous extra-low voltages (< 25 V~ / < 60 V~). The following safety notes provide information about the existing legal regulations. In addition, they include rules of conduct for the responsible teacher for the execution of experiments with hazardous voltage levels.

When performing experiments with electrical energy, it must be absolutely sure that the persons involved in the experiment cannot come into contact with hazardous voltage. The professional (teacher) who supervises/conducts the experiment is responsible for this.

In the "Safety requirements for electrical equipment for measurement, control, and laboratory use" (DIN EN 61010-1, VDE 0411 part 1) of the European Union, non-hazardous voltage is defined as voltage < 33 V~ or < 70 V~ or, in the case of higher voltage, with a limited current of 0.5 mA~ and 2 mA~ maximum.

Other restrictions for schools providing general education have been decreed by the standing conference of the minister of education and cultural affairs of Federal Republic of Germany in the "Directives concerning safety during lessons" (GUV-SI 8070) with reference to the standard VDE 0105 part 12 ("Operation of power installations - Particular requirements for experiments with electrical energy in lecture rooms"). In these directives, the voltage limits for students up to the German class level 10 (age approximately 16 years) have been fixed at 25 V~ and 60 V~ maximum.

Professionals (usually teachers) and students of class levels higher than level 10 may work with hazardous voltages in exceptional cases, if the teaching objective cannot be reached with non-hazardous voltage. In this case, the teacher must be present during the experiment.

The following rules and regulations should be observed:

1. Electrical safety

(DIN EN 61010-1, VDE 0105 part 12, GUV-SI-8070)

Prior to the first experiments of students, trainees, or apprentices with electrical energy in a laboratory or classroom, the students, trainees, and apprentices must be informed in detail about the hazards of the electrical current and about the applicable safety instructions.

Prior to using the electrical devices, they must be checked for signs of damage! Do not use the device if it is damaged!

The operating instructions of the equipment that is used for the experiment must be followed!

Do not use hazardous voltages (> 25 V~ and > 60 V~) in student experiments!

The professional must re-check the experiment set-up (circuit) prior to the start of the experiment and inform the user of any potential hazards!

Modifications of the experiment set-up (set-up, conversion, and take-down) must only be performed when the set-up is completely disconnected from the power supply and when all poles of the supply voltage are switched off!

If measurements or adjustments are unavoidable during an experiment with hazardous voltage, work only with one hand and hold the other behind the back or put it in a pocket!

Ensure that there is a sufficient number of emergency OFF switches in the laboratory.

Use only 4-mm safety cables that are protected against accidental contact (e.g. PHYWE ref. no. 07336-01) when performing experiments with hazardous voltages!

After the completion of the experiment, it should be taken into consideration that component parts, such as capacitors, may supply hazardous voltage even some time after the equipment has been switched off!

Experiments with set-up transformers require special safety measures. Even if the primary side of the transformer is supplied with extra-low voltage (< 25 V~), very high hazardous voltages may be generated on the secondary side by the transformation, e.g. if the coils get mixed up!

If demonstration experiments are performed with hazardous voltages, the teacher or lecturer must ensure a sufficient safety distance from the students. In addition, these kinds of experiments must be marked with the danger sign "High voltage!" (PHYWE ref. no. 06543-00)!

Experiments that are directly supplied with mains power must not be performed unless a residual current circuit breaker (< 30 mA), e.g. a safety plug/socket assembly (PHYWE ref. no. 17051-93) or a variable isolating transformer (PHYWE ref. no. 13535-93), has been installed before the set-up. Do not plug the 4-mm connecting cables directly into the earthing contact socket outlet (SCHUKO socket)!

If power supply units (e.g. power supply unit for students, PHYWE ref. no. 13505-93) are used that do not produce hazardous voltages (extra-low voltages < 25 V~ and < 60 V-), simple, unprotected 4-mm connecting cables and other non-insulated components may also be used for student experiments.

2. EMC (electromagnetic compatibility) (Technical recommendation concerning the application of the EMC Act on electrical teaching equipment, Reg TP 322 TE01)

Experiment set-ups for the demonstration of physical processes must only be used in science rooms at schools, universities, and other educational institutions!

The teacher (expert) who sets up and performs the experiments is responsible for the compliance with the requirements for the EMC Act on the electromagnetic compatibility of equipment! The experiment set-ups do not require a CE mark or declaration of conformity, but the teacher as an expert must take all the necessary measures in order to avoid interferences in the environment!

Possible EMC measures:

- Ensure shielding and equipotential bonding!
- Keep a sufficiently large distance from sensitive equipment!
- Use short connecting cables (in order to reduce RF emission)!
- Floor coverings that may lead to static charges should be avoided and the body should be discharged prior to touching any sensitive experiment equipment!
- RF emitters, e.g. mobile phones, should not be used in close vicinity of the experiment set-up!
- Critical experiment set-up and devices (e.g. Van de Graaf generator, Ruhkoeff induction coil, transmitter), which can cause interferences even at a distance of several 100 metres should be switched on as briefly as possible.

2.) Experiments using lasers

In general, the "Directives concerning safety during lessons" (GUV-SI 8070) are applied at schools. In accordance with these directives, the following points must be observed when working with lasers:

1. Only lasers of class 1, 1 M, 2, and 2 M1 in accordance with DIN EN 60 825 may be used at schools.
2. Lasers of class 1 M, 2, and 2 M must be kept under lock and key.
3. Prior to setting up and performing experiments with lasers of class 1 M, 2, and 2 M, the students who observe or are involved in the experiment must be informed as to the risk to the eyes that is caused by the laser light.

These lasers must only be used under the supervision of the teacher.

4. The area in which experiments with lasers of class 1 M, 2, and 2 M are performed must be marked with laser warning signs during the operation of the laser. This laser area of experiment set-ups must be secured against accidental access by some form of delimitation.
5. The set-up and performance of experiments with lasers of class 1 M, 2, and 2 M must ensure that looking into the direct laser beam or into the reflected beam is avoided, e.g. with the aid of some kind of screening. If lasers of class 1 M and 2 M are used, the beam cross-section must not be reduced, i.e. these lasers must not be used

in combination with converging components (e.g. magnifying glasses).

6. The use of laser devices of class 3 B or 4 in other educational institutions (universities etc.) must be reported to the responsible accident insurer and to the responsible occupational safety and health authority prior to the first start-up of the lasers.

For the use of laser systems of class 3 B or 4, a competent person must be appointed the laser safety officer in writing.

Additional information concerning the use of lasers can be found in the documents of the German Social Accident Insurance "GUV-V B – Laser radiation" and "GUV-I 832 – Use of laser systems". These documents are mainly based on the EU standard "DIN EN 60825-1 – Safety of laser products".

3.) Handling of radioactive products

In Germany, the handling of radioactive substances is controlled by the German Radiation Protection Ordinance (Strahlenschutzverordnung, StrlSchV). The legal bases of this ordinance are articles 25 to 27 combined with appendix V of the ordinance dated 20 July 2001, last amended by article 2 of the law of 02/08/2008. Substances within the exemption limits (see Appendix V of the German Radiation Protection Ordinance (StrlSchV) for the exemption limits) can be supplied to schools without any conditions. If the exemption limits are exceeded, the school will need a special handling permit issued by the responsible supervisory authority prior to purchasing the substances.

If several substances within the exemption limits are owned and/or purchased, the sum formula that is stated in the German Radiation Protection Ordinance must be observed.

Radioactive substances must be protected against unauthorised persons, which is why they must be stored in a theft-proof manner. In addition, the handling regulations of the German Radiation Protection Ordinance must be observed. Substances that have become unusable must be handed over directly to the responsible collection centre or to a disposal company.

4.) Safety instruction for handling hazardous materials

Before any experimentation with hazardous materials, it is essential that you become familiar with the national and local directives and ordinances concerning the handling of hazardous materials, their storage and transport. The basic principle is that all hazardous materials must be dealt with cautiously and carefully. It is of course required that, in case of experiments, neither the students nor the teachers be exposed to any unnecessary dangers to health. The instructions

of the safety data sheets for the individual materials, in the most current version in each case, are to be considered, as well as the accident-prevention specifications and the respective workplace-related operating instructions. The waste disposal of used hazardous materials must be implemented according to recognized methods. The local specifications for the proper removal of chemical residues are to be considered in this case.

General Terms and Conditions (GTC)

of PHYWE Systeme GmbH & Co. KG

§ 1 Application of Conditions

1. These General Terms and Conditions (hereinafter referred to as GTC) shall apply for all goods, services and offers of PHYWE Systeme GmbH & Co. KG (hereinafter referred to as PHYWE) for its customers (hereinafter referred to as Customer). They shall apply equally for all future business between the contract parties without requiring a repeated reference. General Terms and Conditions of the Customer shall apply only if expressly approved by PHYWE in writing.
2. All deviating agreements between PHYWE and the Customer shall be set down in writing; a waiver of the written form does not have any effect on the agreement's validity. In the event of such an agreement these GTC shall be of lesser importance and shall supplement the agreement.
3. PHYWE reserves all rights to PHYWE operational and offer documents. If no order is placed, all documents shall be returned immediately of the Customer's own accord. All information in them and from other transactions shall be treated as strictly confidential.
4. All offers, samples and test products as well as their technical data and descriptions in the respective product information and promotional materials on the PHYWE website are for information only and are not binding. They do not represent a warranty of quality or application.
5. Insofar as PHYWE considers it necessary for the completion of its performances, PHYWE is authorized to exchange job-related data with assistants or trading partners. If the Customer does not desire such an information exchange, the Customer may object to it in writing at any time.

§ 2 Offer and Contract Conclusion

PHYWE's offers are not binding. PHYWE reserves an acceptance period of two weeks from receipt at PHYWE regarding the Customer's binding orders. Verbal statements of acceptance (by phone) and all Customer orders shall be confirmed by PHYWE in writing or by telex; a waiver of the confirmation does not affect the effectiveness of verbal statements of acceptance and orders (by telephone).

§ 3 Prices

1. The prices given in the PHYWE price list or the PHYWE order confirmation, exclusive of the relevant applicable value-added tax in the respective country, shall be binding. Additional goods and services are charged separately.
2. The prices are "ex work PHYWE" and include PHYWE standard packaging. Special packaging or other requests from the Customer, such as packaging in certain lots, are charged separately. Deviating provisions may be agreed between PHYWE and the Customer or by PHYWE for a region or a country in writing from time to time.

§ 4 Delivery and Performance Terms

1. Delivery dates or terms that may be agreed upon, both binding and unbinding, shall be set down in writing. Non-binding delivery terms may be exceeded by up to 8 weeks by PHYWE; only after expiration of this term we shall fall into arrears by reminder of the Customer. Delivery terms shall start as of contract conclusion and acceptance of payment details by PHYWE. In the event that changes to the contract are agreed upon, it is subsequently required to agree on a new delivery date at the same time. Claims for damages or recourse of the Customer towards PHYWE shall be excluded in any case.
2. In the event of delivery and performance delays due to force majeure, natural disasters as well as due to labour disputes, traffic or operation disturbances, lack of material through no fault of their own and similar reasons on PHYWE and its suppliers' part, the Customer is not entitled to withdraw from the contract or to assert claims towards PHYWE. The Customer is entitled to withdraw from the contract if the aforementioned reasons cause an extension of the delivery date by more than four months. PHYWE is entitled equally to withdraw from the contract. Claims for damages or recourse of the Customer towards PHYWE shall be excluded in any case.

3. PHYWE is entitled to make partial deliveries and partial performances at any time unless the deliveries and performances are to be made fully and completely in accordance with the contractual arrangements.
4. PHYWE's compliance with delivery and performance obligations requires the Customer's timely and proper compliance with its obligations.
5. If the Customer falls into arrears, PHYWE is entitled to demand reimbursement of the additional expenses it had to make for the unsuccessful offer and storage and maintenance of the owed object; with commencement of default of acceptance the risk of incidental deterioration and accidental loss is transferred to the Customer.

§ 5 Export Business

PHYWE is entitled to withdraw from the contract regarding delivery of such products (partial withdrawal) that require approval of the federal ministry for economics and export control, the Federal Institute for Medicaments and Medical Products or a similar governmental institution for their export from Germany or their import in their country of destination pursuant to legal provisions in the event that the approval is not issued or probably may not be obtained until the agreed delivery date. PHYWE shall immediately advise the Customer of this and possibly reimburse a compensation for the part of the performance affected by the withdrawal.

§ 6 Shipping and Transfer of Risk

1. Place of performance is Göttingen. The delivery condition is "ex works PHYWE". Other agreements must be made in writing.
2. The Customer may request PHYWE to ship the goods. It shall bear the costs and risk for it. In the case of a forwarding order the risk is transferred to the Customer as soon as the shipment had been handed over to the person executing the transport. If PHYWE is able to ship the goods at the time determined by contract and the shipment is delayed at the Customer's request the risk is transferred to the Customer at notice of readiness for shipment.
3. At the Customer's request shipments shall be insured in its name and on its account.

§ 7 Claims for Defects/Guarantee

1. PHYWE is working pursuant to the guarantee claims typical in Germany and the EU. If a PHYWE product shows any other defect already present at delivery, the Purchaser shall advise it immediately and provide evidence. In such an event PHYWE shall repair the defect or deliver a product free of defects (supplementary performance) pursuant to legal provisions. PHYWE shall bear the expenses required for the purposes of supplementary performance, including but not limited to transport, labour and material cost. Additional expenses caused by the sold product being brought to a place other as the domicile or the branch office of the Customer shall not be borne by PHYWE.
2. Insignificant or commercial deviations of the delivered goods in size, shape and colour being in the material's nature do not establish claims for defects by the Customer. Article 377 German Commercial Code applies.
3. PHYWE reserves the right to changes to the PHYWE products required for technical or other reasons not affecting usability and not reducing the service's value and for technical improvements. They do not establish claims for defects, abatement or withdrawal from the transaction by the Customer.
4. If PHYWE's operation or maintenance instructions are not adhered to, changes to the products are made, parts are exchanged or consumables not complying with the original specifications are used, the Customer may not assert claims for defects if the Customer does not refute a substantiated claim to the effect that it was only one of those circumstances that had caused the defect.
5. The Customer must immediately inform customer service management/PHYWE's technical hotline of visible defects in writing, however, the latest within one week after receiving and/or accepting the

delivered goods. Defects that can not be discovered within this period even with careful examination shall be communicated and proven to PHYWE in writing immediately upon discovery.

6. Claims for defects for regular wear and tear are excluded.
7. Only the immediate Customer is entitled to claims for defects towards PHYWE and may not transfer them to third parties.
8. Claims for defects fall under the statute of limitations after 12 months as of delivery of the goods under contracts with the Customer. Retaining payments by the Customer is only admissible if the proportion of the occurred defect is appropriate.

§ 8 Repairs

If the Customer is not entitled to claims for defects pursuant to § 7 or if the statutory period of limitation pursuant to § 7.8 is expired and PHYWE and the Customer agree on a repair of the products § 7.8 applies equally to the limitation of a defect of the repair.

§ 9 Reservation of Title

1. PHYWE reserves title to the goods until fulfilment of all claims from the business relation for whatever legal reason including the claims arising in the future or conditional claims. If the realisable value of existing securities (goods subject to reservation of title pursuant no. 3 below and transferred accounts receivable pursuant no. 5 below) exceeds the secured claims by more than 10 % in total PHYWE is obliged insofar to release securities at the seller's discretion at the Customer's request.
2. Joint ownership rights arising from combination or mixing are deemed goods subject to reservation of title. PHYWE has an appropriate right to the reservation of title on these goods as well.
3. The Customer is entitled to process and sell the goods subject to reservation of title in the course of normal business unless it falls into arrears. Pledging or protective conveyance is inadmissible. By way of security the customer shall immediately transfer to PHYWE all claims (including any outstanding balance claims from the current accounts) arising from the resale or another legal reason (insurance, inadmissible action) in connection with the goods subject to reservation of title to their full extent. PHYWE shall give it the revocable authorization to collect the claims transferred to PHYWE for its account in its own name. This authorization for collection may only be withdrawn if the Customer does not properly fulfil its payment obligations.
4. In the event that the Customer behaves contrary to the contract – including but not limited to falling into arrears – PHYWE is entitled to take back the goods subject to reservation of title after expiration of an appropriate additional respite or demand the transfer of the Customer's claims for return towards third parties as the case may be. PHYWE taking back the goods subject to reservation of title does not constitute a withdrawal from the contract unless PHYWE has expressly stated such withdrawal.

§ 10 Payment

1. All payments exceeding the credit limit of the Customer with PHYWE confirmed by PHYWE in writing shall be made for payment in advance or confirmed with an irrevocable letter of credit from a large European bank accepted by PHYWE or an equivalent bank guarantee.
2. Within or above credit limit invoices shall be payable without deducting a cash discount or other discounts with PHYWE receiving the payment within 20 days as of contract conclusion and receipt of the invoice or an equivalent payment listing by the Customer.
3. In the event of orders with a purchase price surpassing € 25,000.00 the Customer shall make an advance payment of 40% of the purchase price for PHYWE products and 60% of the purchase price for third party products. The advance payment is due on contract conclusion and receipt of an invoice or equivalent payment listing.
4. A payment is only deemed made when PHYWE has the amount at its disposal. In case of cheques the payment is only deemed made when the cheque has been cashed.

5. The Customer shall fall into arrears 3 days after maturity of the claim by PHYWE and receipt of an invoice or delivery without it requiring a written reminder. If the Customer falls into arrears PHYWE is entitled to demand interest of 8% above the relevant basic interest rate of the European Central Bank at the respective point in time. PHYWE may submit evidence of a greater damage.
6. If PHYWE becomes aware of circumstances calling the Customer's financial standing into question, including but not limited to not cashing its cheque or stopping its payments, or if PHYWE becomes aware of other circumstances calling the Customer's financial standing in question, PHYWE is entitled to call the complete outstanding debts even if it had accepted cheques.
7. The Customer is only entitled to set off its debts if the counterclaims have been established as final and absolute or are undisputed. The same shall apply for the right of retention pursuant to article 273 German Civil Code, the commercial right of retention pursuant to article 369 German Civil Code and the right of refusal of services pursuant to article 320 German Civil Code.

§ 11 Copyright Infringements

1. PHYWE shall exempt the Customer and its customers from claims arising from infringements of copyrights, trade marks or patents unless the design of a delivery object had been made by the Customer. PHYWE's exemption obligations shall be limited to the amount of the predictable damage. An additional requirement for exemption is that in case of a legal dispute (article 72 German Code of Civil Procedure) the Customer informs PHYWE of the dispute and that the alleged legal infringement may be ascribed to the construction of PHYWE's delivery items without combination or use with other products.
2. Optionally PHYWE has the right to free itself from the obligations assumed in clause 1 by either
 - a) obtaining the required licences regarding the alleged infringed patents, or
 - b) providing the Customer with a changed delivery item or part of it that rectifies the infringement reproach concerning the delivery item by exchanging it for the infringing delivery items or their parts unless the changed delivery item (or parts of it) falls behind the original performance regarding the usability and/or its value.

§ 12 Liability

1. PHYWE shall be liable for breaches of contractual and non-contractual obligations, including but not limited to impossibility, delay and unlawful acts, only in cases of malicious intent and gross negligence – of its executive employees as well – limited to damages foreseeable at contract conclusion.
2. Claims for damages of material defects shall fall under the statute of limitation after 12 months as of delivery of the goods – with exception of personal injury or wilful or grossly negligent breaches of duty. The limitation of legal regress claims remains unaffected. The relevant legal provisions apply for claims for damages on account of other legal reasons.

§ 13 Applicable law, jurisdiction, partial invalidity

1. In addition to these provisions German law with exemption of the provisions of the UN Convention on Contracts for the International Sale of Goods dated 11/04/1980 (CISG) applies.
2. Place of jurisdiction is Göttingen.
3. If a provision in these General Terms and Conditions or a provision under other agreements is or becomes ineffective the validity of all other provisions or agreements shall remain unaffected.

General Terms and Conditions of PHYWE Systeme GmbH & Co. KG, last updated on 01/08/2010

After announcement of new General Terms and Conditions all previous General Terms and Conditions lose their validity.

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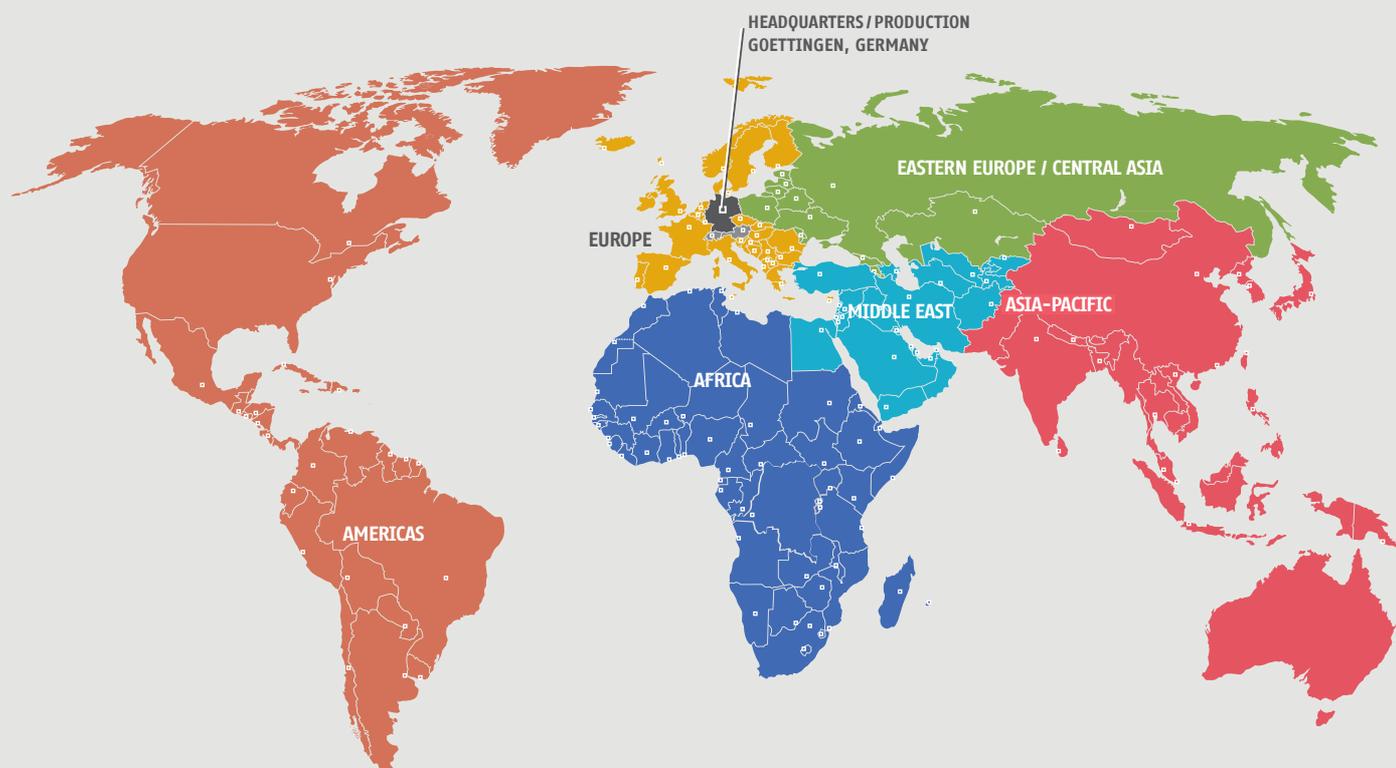
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