PHYSICS

CHEMISTRY
BIOLOGY

ENGINEERING

LD DIDACTIC

Science Teaching Modules Physics

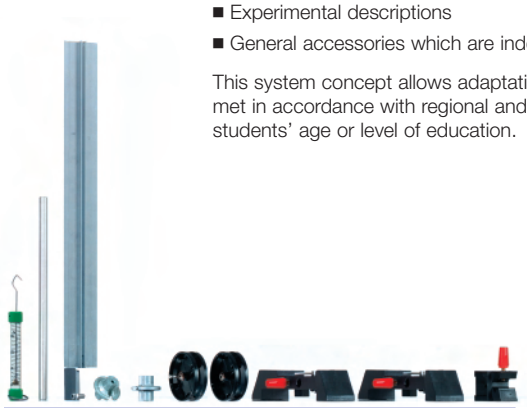
STM: 1 system, 5 branches
441 experiments

Science **T**eaching **M**odules (STM) is a modular experiment system for the subjects of physics, chemistry, and biology. Each subject is subdivided into topics, e.g., mechanics, which are further subdivided into groups of items such as forces/simple machines. For every item, an STM module is supplied.

An STM module consists of several components:

- Specific apparatus for the experiments
- Storage cases fitting the shape of the apparatus in sets or blocks depending on your choice
- Experimental descriptions
- General accessories which are independent of the system

This system concept allows adaptation to a wide range of requirements to be met in accordance with regional and national curricula, text books, and students' age or level of education.



Apparatus

- Ease of use
- Clear, functional design
- Robust, stable and durable
- Many experiments with few apparatus
- Ideal combination of sets of apparatus in accordance with curricula
- Minimal preparation set-up time for teachers
- Extendable up to the level of secondary education, e.g., wave optics, mechanical oscillations and waves, electric fields.

Experimental descriptions and manuals

- Easy-to-understand worksheets for students
- Objects of the experiments, preparation, carrying out the experiments and evaluation are presented in a clear structure
- Comprehensive information with experiment results for teachers
- Prepared tables for entering the measuring results
- Suitable for copying for use at schools

Storage

- Stackable cases for space-saving and well-organized storage
- Apparatus are handed out and put away in little time
- Completeness can be checked quickly after the experiments because the cases fit the shape of the apparatus
- Different fields are distinguished by the colour of the labels

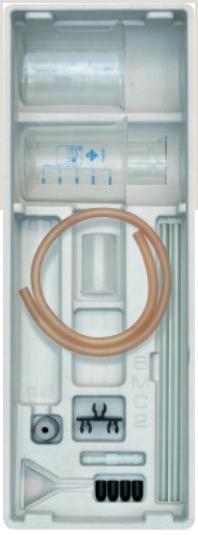
2 Storage possibilities

STM apparatus

Storage in sets

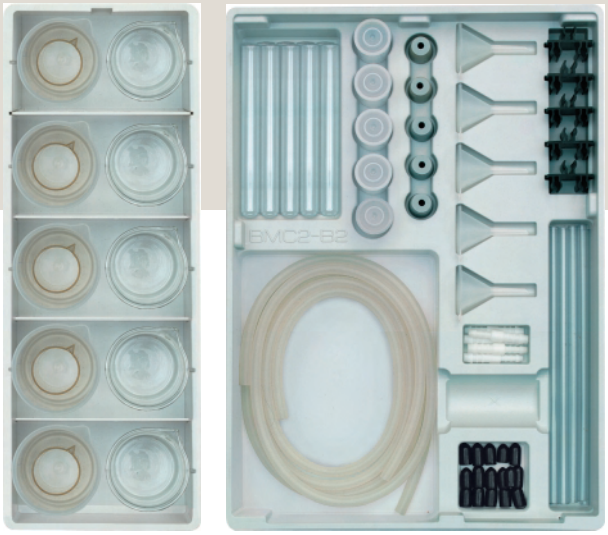
In every case all apparatus needed by **one** group of students are contained.

STM set of apparatus



Storage in blocks

In the cases apparatus needed by several groups of students (**e.g. 5**) are contained.



STM block of apparatus

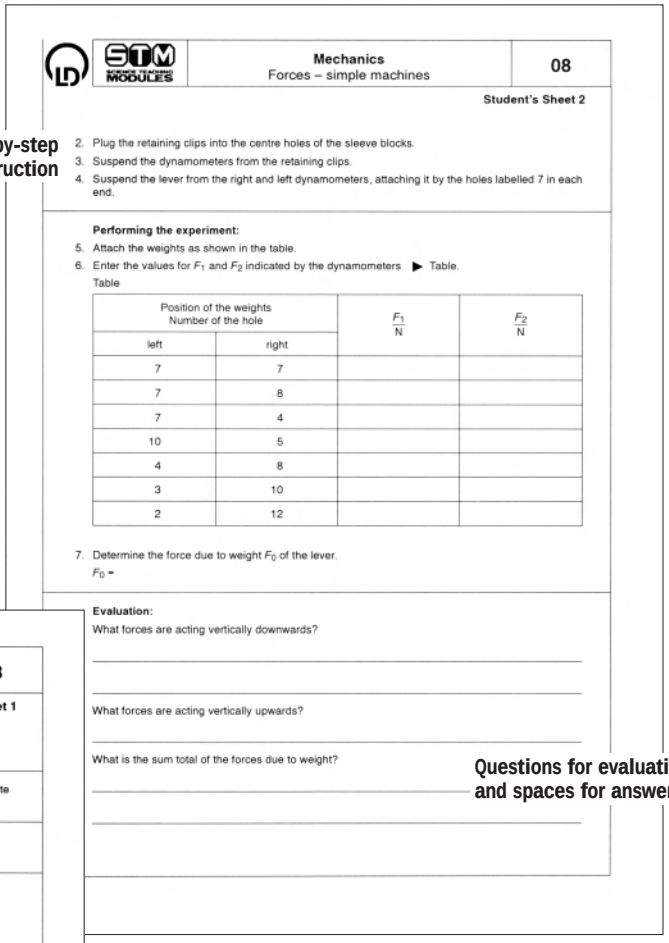
Storage of the cases

In Leybold cupboards (801 026 or 801 045) or standard cupboards.

STM Experiment description and manual

Experiment descriptions and manuals are available in English, German, French and Spanish

Step-by-step instruction



STM Mechanics Forces – simple machines 08

Student's Sheet 2

2. Plug the retaining clips into the centre holes of the sleeve blocks.
3. Suspend the dynamometers from the retaining clips.
4. Suspend the lever from the right and left dynamometers, attaching it by the holes labelled 7 in each end.

Performing the experiment:

5. Attach the weights as shown in the table.
6. Enter the values for F_1 and F_2 indicated by the dynamometers ▶ Table.

Table

Position of the weights Number of the hole		F_1 N	F_2 N
left	right		
7	7		
7	8		
7	4		
10	5		
4	8		
3	10		
2	12		

7. Determine the force due to weight F_0 of the lever.
F_0 =

Evaluation:

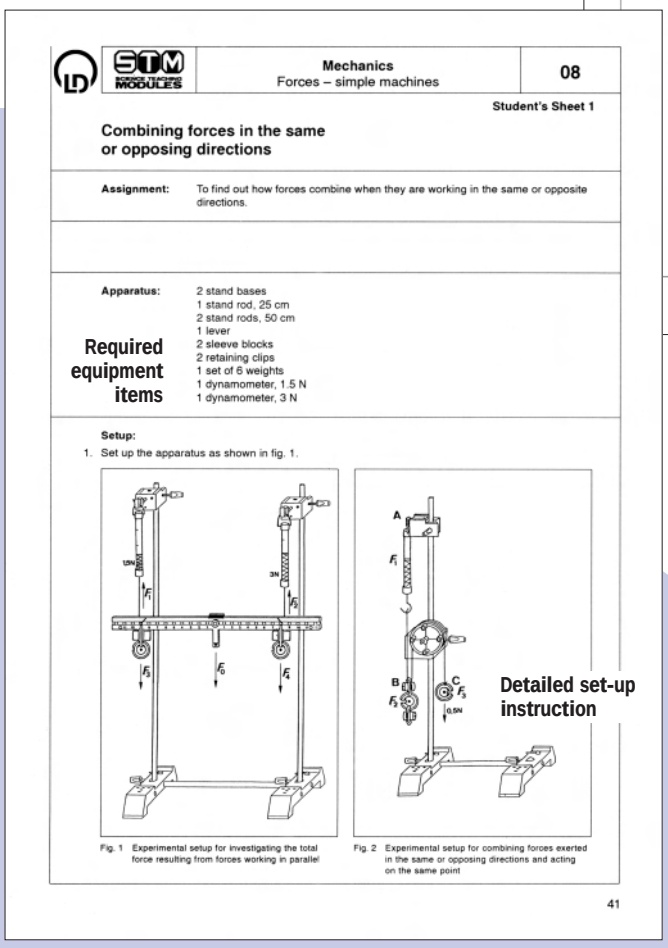
What forces are acting vertically downwards?

What forces are acting vertically upwards?

What is the sum total of the forces due to weight?

Questions for evaluation and spaces for answers

Pupil's worksheet for experiment evaluation
Prepared tables of results and coordination diagrams



STM Mechanics Forces – simple machines 08

Student's Sheet 1

Combining forces in the same or opposing directions

Assignment: To find out how forces combine when they are working in the same or opposite directions.

Apparatus:
2 stand bases
1 stand rod, 25 cm
2 stand rods, 50 cm
1 lever
2 sleeve blocks
2 retaining clips
1 set of 6 weights
1 dynamometer, 1.5 N
1 dynamometer, 3 N

Required equipment items

Setup:

1. Set up the apparatus as shown in fig. 1.

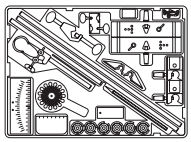
Fig. 1 Experimental setup for investigating the total force resulting from forces working in parallel

Fig. 2 Experimental setup for combining forces exerted in the same or opposing directions and acting on the same point

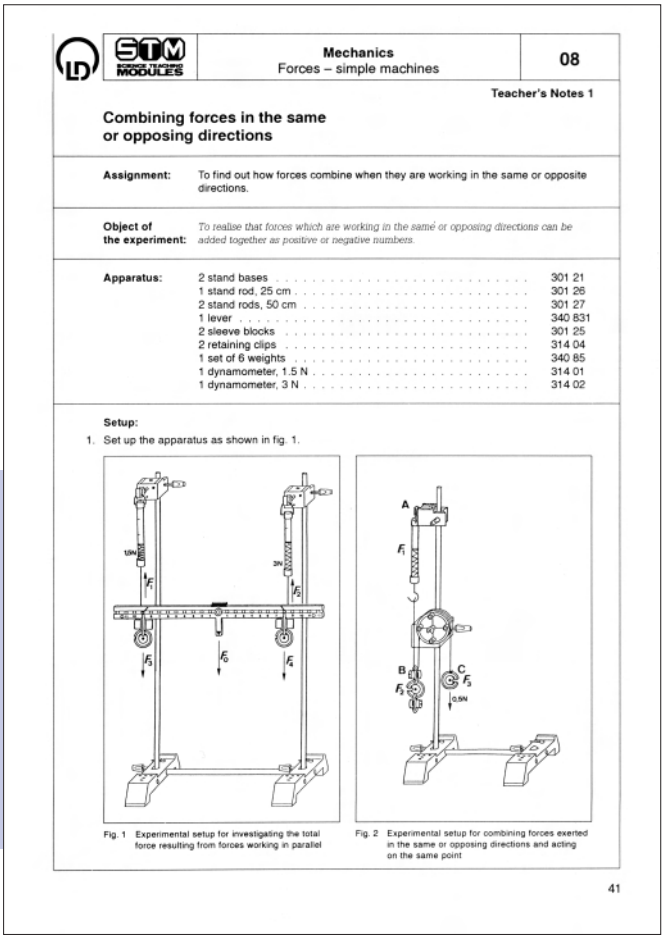
Detailed set-up instruction

41

Pupil's worksheet



- Teacher's guide and
- pupil's worksheet (to be photocopied) together in a ring folder
- easy-to understand worksheets for the pupils
- clearly structured documentation, giving experiment objectives, preparatory tasks, experiment procedures, analysis of results, and safety instructions
- detailed background and support information for the teacher, together with experiment result



LD STM Mechanics Forces – simple machines 08

Teacher's Notes 1

Combining forces in the same or opposing directions

Assignment: To find out how forces combine when they are working in the same or opposite directions.

Object of the experiment: *To realise that forces which are working in the same or opposing directions can be added together as positive or negative numbers.*

Apparatus:

2 stand bases	301 21
1 stand rod, 25 cm	301 26
2 stand rods, 50 cm	301 27
1 lever	340 831
2 sleeve blocks	301 25
2 retaining clips	314 04
1 set of 6 weights	340 85
1 dynamometer, 1.5 N	314 01
1 dynamometer, 3 N	314 02

Setup:

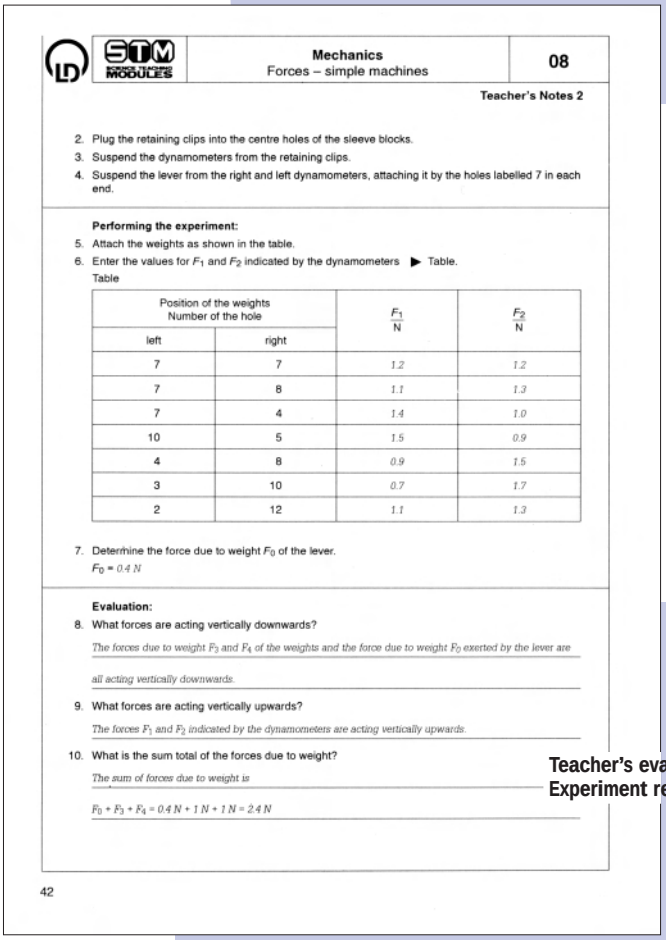
1. Set up the apparatus as shown in fig. 1.

Fig. 1 Experimental setup for investigating the total force resulting from forces working in parallel

Fig. 2 Experimental setup for combining forces exerted in the same or opposing directions and acting on the same point

41

Teacher's worksheet



LD STM Mechanics Forces – simple machines 08

Teacher's Notes 2

2. Plug the retaining clips into the centre holes of the sleeve blocks.
3. Suspend the dynamometers from the retaining clips.
4. Suspend the lever from the right and left dynamometers, attaching it by the holes labelled 7 in each end.

Performing the experiment:

5. Attach the weights as shown in the table.
6. Enter the values for F_1 and F_2 indicated by the dynamometers ▶ Table.

Table

Position of the weights Number of the hole		F_1 N	F_2 N
left	right		
7	7	1.2	1.2
7	8	1.1	1.3
7	4	1.4	1.0
10	5	1.5	0.9
4	8	0.9	1.5
3	10	0.7	1.7
2	12	1.1	1.3

7. Determine the force due to weight F_0 of the lever.
$F_0 = 0.4$ N

Evaluation:

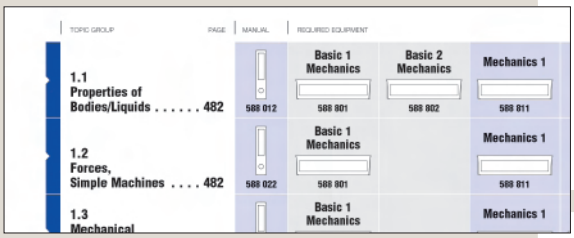
8. What forces are acting vertically downwards?
The forces due to weight F_3 and F_4 of the weights and the force due to weight F_0 exerted by the lever are all acting vertically downwards.
9. What forces are acting vertically upwards?
The forces F_1 and F_2 indicated by the dynamometers are acting vertically upwards.
10. What is the sum total of the forces due to weight?
The sum of forces due to weight is
$F_0 + F_3 + F_4 = 0.4$ N + 1 N + 1 N = 2.4 N

42

Teacher's evaluation sheet
Experiment results and their interpretation

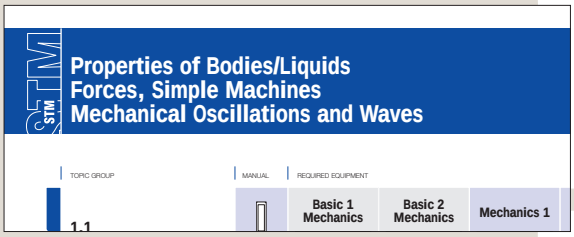
STM: from the topic to the order

From which fields can experiments been carried out?

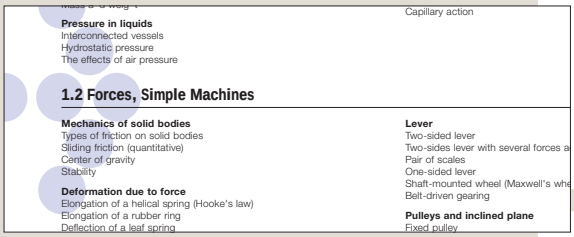


An overview of the topics is given on page 8/9.

Which experiments within a group of topics can be carried out?

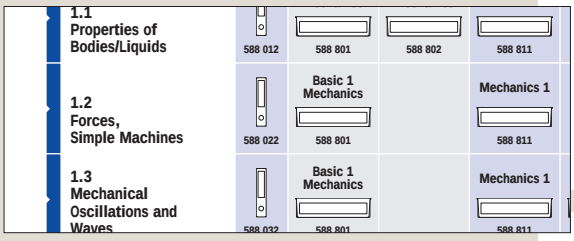


The groups of topics are compiled on pages 10 to 23.



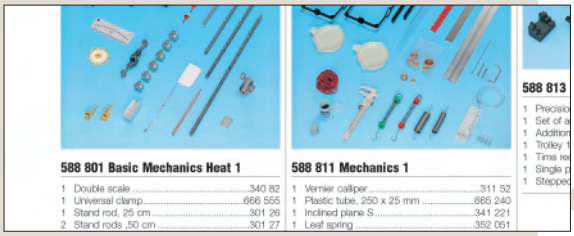
For example, group of topics 1.2 forces, simple machines with the experiment “Two-sided lever”.

Which apparatus and which book are needed?

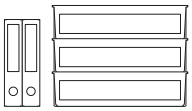


On pages 10/11, the required apparatus and manuals are also listed:

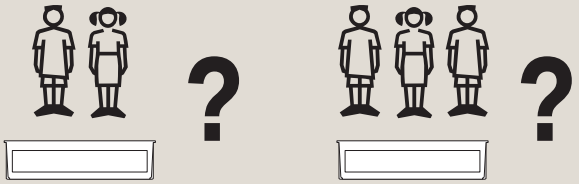
Manual	588 022
Basis 1	588 801
Mechanics 1	588 811



The list of content of the equipment sets are depicted on pages 24 to 28.

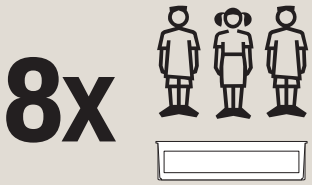


Science Teaching Modules
How to order



We propose two or three students for one group.

How much material is needed for a class?



If, for example, 24 students are divided into groups of 3 students each, material for 8 groups is needed.

storage in sets…

The students always get all apparatus related to one field (e.g. mechanics) at their workplace. Place the following order, while setting a »S« behind the Cat. No.:

Are the apparatus to be stored in sets or blocks?
(See page 3)

ORDER

QUANTITY	DESIGNATION	CAT. NO.
1	MANUAL: FORCES/SIMPLE MACHINES	588 022
8	BASIS 1	588 801 S
8	MECHANIK 1	588 811 S

or storage in blocks

The teacher gives the students only those apparatus they need for a particular experiment. If the apparatus are stored in blocks, less space in the cupboard is needed. Place the following order, while setting a »B« and the number of groups behind the cat. no.:

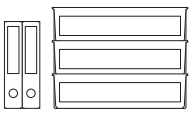
ORDER

QUANTITY	DESIGNATION	CAT. NO.
1	MANUAL: FORCES/SIMPLE MACHINES	588 022
1	BASIS 1	588 801 B 8
1	MECHANICS 1	588 811 B 8

Accessories (measuring instruments and power supplies) and consumable material are shown on page 28.

Summary of topic groups
Mechanics · Heat · Electrostatics
Electricity

TOPIC GROUP	PAGE	MANUAL	REQUIRED EQUIPMENT				
1.1 Properties of Bodies/Liquids	10	588 012	Basic 1 Mechanics 588 801	Basic 2 Mechanics 588 802	Mechanics 1 588 811		
1.2 Forces, Simple Machines	10	588 022	Basic 1 Mechanics 588 801		Mechanics 1 588 811		
1.3 Mechanical Oscillations and Waves	10	588 032	Basic 1 Mechanics 588 801		Mechanics 1 588 811	Mechanics 2 588 812	
1.4 Linear Motion	12	589 042					Mechanics 3 588 813
2.1 Thermal Expansion, Heat Propagation and Energy, States of Matter	13	588 152	Basic 1 Mechanics 588 801	Basic 1 Mechanics 588 802	Heat 1 588 831		
3.1 Electrostatics	14	589 162	Electrostatics 1 588 73				
3.2 Electic Fields	14	589 172	Electrostatics 1 588 73	Electrostatics 2 588 74			
3.3 Magnetic Forces and Fields	14	588 302			Magnetism 1 588 860		
3.4 Basic Electric Circuits	16	588 332	Basic Electricity 588 871	Electricity 1 588 875			
3.5 Electromagnetism and Induction	16	588 342	Basic Electricity 588 871	Electricity 1 588 875	Electricity 2 588 876		
3.6 Generators and Motors	16	588 352	Basic Electricity 588 871		Electricity 2 588 876	Electricity 3 588 877	

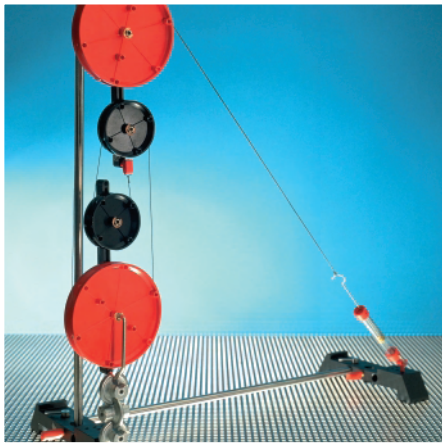


Summary of topic groups
Electricity · Electronics · Opto Electronics
Optics · Radioactivity

TOPIC GROUP	PAGE	MANUAL	REQUIRED EQUIPMENT				
3.7 Electrochemistry	16	588 402					Electrochemistry 588 873
4.1 Basic Electronic Circuits	18	588 422	Basic Electrics 588 871		Electronics 1 588 881		
4.2 Transistor Applications	18	588 432	Basic Electrics 588 871	Electrics 2 588 876	Electronics 1 588 881	Electronics 2 588 882	
4.3 Opto Electronics	18	588 442	Basic Electrics 588 871		Electronics 1 588 881	Electronics 2 588 882	Electronics 3 588 883
5.1 Geometrical Optics with the Raybox	20	588 202	Optics Raybox 588 845				
5.2 Geometrical Optics on the Precision Metal Rail	20	588 212	Basic Optics 588 840	Optics 1 588 841			
5.3 Colour Mixing	20	588 222	Basic Optics 588 840		Optics 2 588 842		
5.4 Diffraction	22	589 252 589 262	Basic Optics 588 840			Optics 3 588 843	
5.5 Polarization	22	589 272	Basic Optics 588 840				Optics 4 588 844
6.1 Radioactivity	23	588 482	Radioactivity 588 855				

Properties of Bodies/Liquids
Forces, Simple Machines
Mechanical Oscillations and Waves

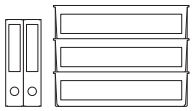
TOPIC GROUP	MANUAL	REQUIRED EQUIPMENT				
1.1 Properties of Bodies/Liquids	588 012	Basic 1 Mechanics 588 801	Basic 2 Mechanics 588 802	Mechanics 1 588 811		
1.2 Forces, Simple Machines	588 022	Basic 1 Mechanics 588 801		Mechanics 1 588 811		
1.3 Mechanical Oscillations and Waves	588 032	Basic 1 Mechanics 588 801		Mechanics 1 588 811	Mechanics 2 588 812	



Block an tackle

Pair of scales

Inclined plane



1.1 Properties of Bodies/Liquids

Measuring of length and time
Measuring lengths
Planemetry
Calculating the volume of regularly shaped bodies
Calculating the volume of solid bodies by the amount of liquid displaced
Calculating the volume of gaseous bodies
Measuring time (chronometry)

Measurement of mass and density
Calculating mass
Determination of the density of regularly shaped bodies
Determination of the density of irregularly shaped bodies
Determination of the density of liquids
Mass and weight

Pressure in liquids
Interconnected vessels
Hydrostatic pressure
The effects of air pressure

Forces acting on bodies in liquids
The weight of bodies in water
Buoyancy force as a function of depth of immersion and body mass
Buoyancy force as a function of the density of a fluid
Buoyancy force as a function of the volume of a body
Archimedes' principle
Sinking - floating suspended in a liquid - floating on a liquid

Density of liquids
Calculating density from volume and mass
The areometer

Forces at the surface of liquids
Surface tension
Capillary action

1.2 Forces, Simple Machines

Mechanics of solid bodies
Types of friction on solid bodies
Sliding friction (quantitative)
Center of gravity
Stability

Deformation due to force
Elongation of a helical spring (Hooke's law)
Elongation of a rubber ring
Deflection of a leaf spring

Combining and breaking down forces
Combining forces in the same or opposing directions
Combining forces in specified amounts
Breaking forces down into force components

Oscillations
String pendulum
Bar pendulum
Spring pendulum
Leaf spring oscillations

Lever
Two-sided lever
Two-sides lever with several forces acting upon it
Pair of scales
One-sided lever
Shaft-mounted wheel (Maxwell's wheel)
Belt-driven gearing

Pulleys and inclined plane
Fixed pulley
Movable pulley
Hoist with two pulleys
Block and tackle 1 (open type)
Block and tackle 2 (compacte version)
Forces acting on a inclined plane
Work performed on a inclined plane
Energy conversion

1.3 Mechanical Oscillations and Waves

Pendulum with harmonic oscillations
Thread pendulum
Rod pendulum
Helical spring pendulum
Torsion pendulum
Leaf spring pendulum

Time dependence of pendulum oscillations
Oscillation damping by body friction
Evaluation of registered leaf spring oscillations
Distance/time and speed/time diagrams of harmonic oscillations
Forced oscillations
Forced oscillations of pendulums
Forced oscillations of rod pendulum with amplitude recording

Linear superposition of oscillations
Linear superposition of oscillations, amplitude, phase and frequency dependences
Oscillations of mechanically coupled rod pendulums
Oscillations of magnetically coupled leaf spring pendulums with oscillation recording

Formation of waves (wave machine)
Energy transport in longitudinal and transversal waves
Standing transversal waves and longitudinal waves with loose and fixed ends

Standing waves
Frequencies of standing cord waves
Phase velocity of cord waves
Phase velocity of helical spring waves
Standing helical spring waves
Oscillation nodes and antinodes as a function of the excitation frequency

Superpositioning of cord waves
Superposition of cord waves of identical frequency
Superposition of cord waves with a slight frequency

Linear Motion

TOPIC GROUP

1.4 Linear Motion

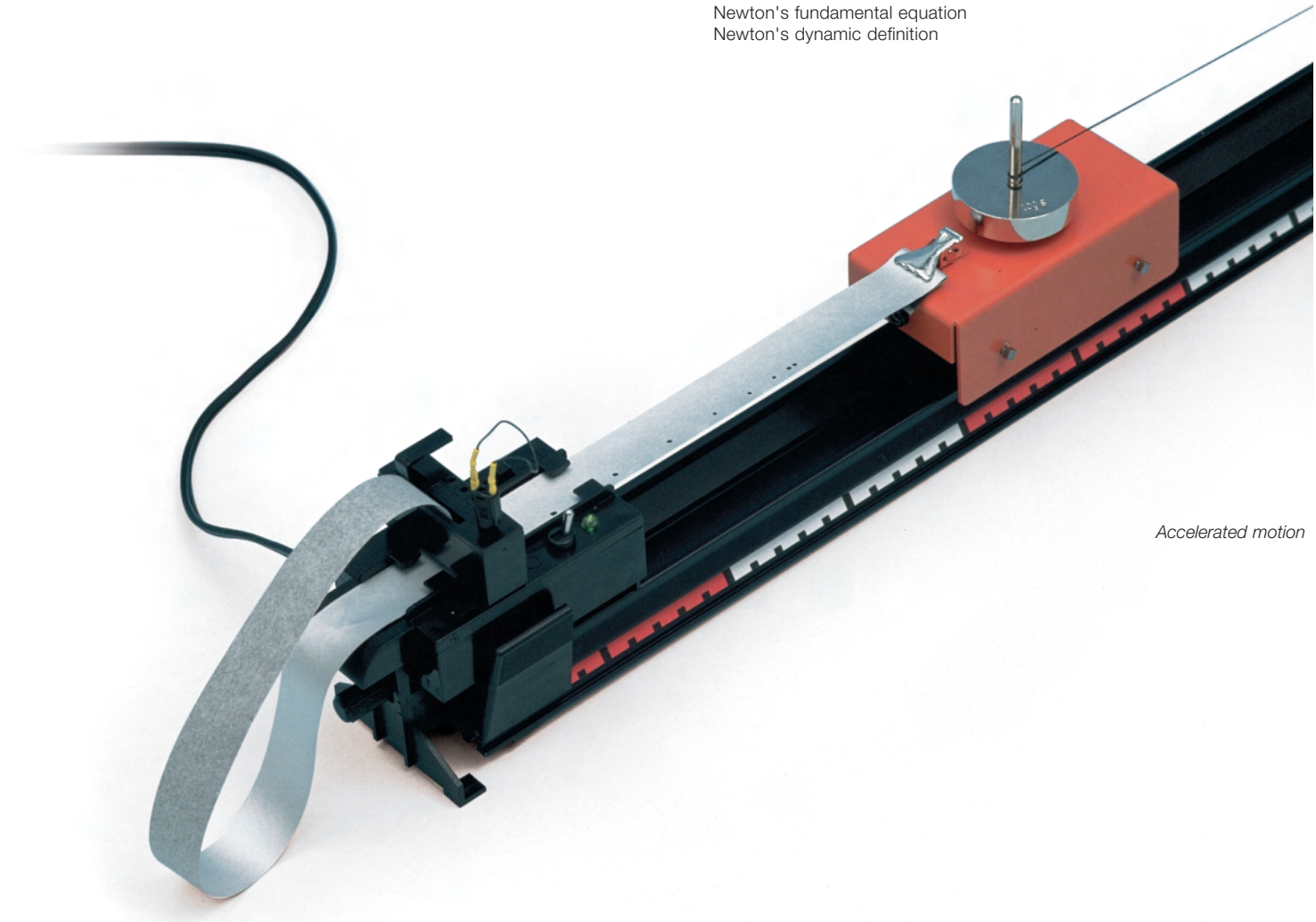
MANUAL	REQUIRED EQUIPMENT				
589 042					Mechanics 3 588 813

TOPICS

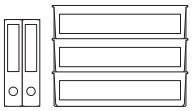
1.4 Linear Motion

Regular motion
Momentary velocity
Friction
Rectolinear and regular motion
Spacer/time and velocity diagram
Accelerated motion
Uniformly accelerated motion
Velocity change with acceleration

Accelerated motion: position/time and velocity/time diagram
Determining final velocity I
Determining final velocity II
Quantitative relationships of an accelerated motion
Free fall
Newton's fundamental equation
Newton's dynamic definition



Accelerated motion



Thermal Expansion, Heat Propagation and Energy, States of Matter

TOPIC GROUP

2.1 Thermal Expansion, Heat Propagation and Energy, States of Matter

MANUAL

588 152

REQUIRED EQUIPMENT

Basic 1 Mechanics	Basic 2 Mechanics	Heat 1
		
588 801	588 802	588 831

TOPICS

2.1 Thermal Expansion, Heat Propagation and Energy, States of Matter

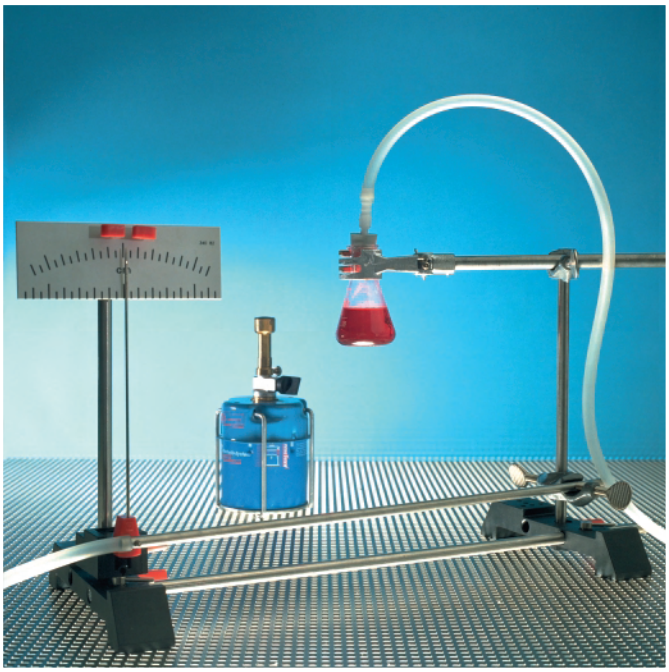
Thermal expansion
Thermal properties of water
Calibration a thermometer
Linear expansion of solid bodies
Thermal properties of a bimetal
Heating air (at a constant pressure)
Heating air (at constant volume)

Heat transfer
Termal conduction in solid bodies
Heat transfer in liquids
Heat transfer in gases
Changes in temperature causes by thermal radiation

Themal insulation
Cooling down water

Heat capacities
Heating up different volumes of water
Heating of different liquids
Mixtire temperature
Specific heat capacity of water
Specific heat capacity of solid bodies
Heat capacity of a calorimeter

States of aggregation and transition
Temperature changes during heating
Fusion heat of ice
Condensation of water vapor
Temperatures in water-salt mixtures
Distillation

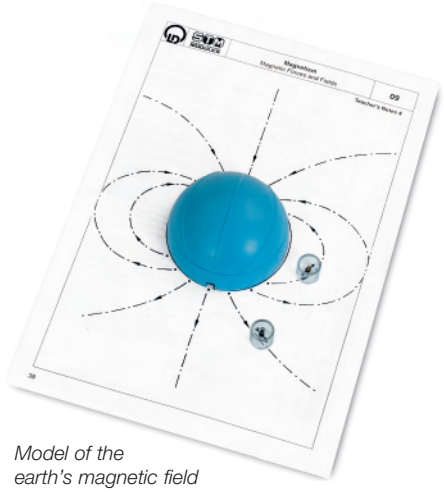


Linear expansion of solid bodies

Electrostatics
Electric Fields
Magnetic Forces and Fields

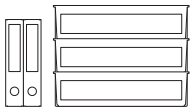
TOPIC GROUP	MANUAL	REQUIRED EQUIPMENT				
3.1 Electrostatics	588 162	Electrostatics 1 588 73				
3.2 Electic Fields	588 172	Electrostatics 1 588 73	Electrostatics 2 588 74			
3.3 Magnetic Forces and Fields	588 302				Magnetism 2 588 860	

Charges on a Faraday Cup



Model of the earth's magnetic field

Recording equipotential lines



3.1 Electrostatics

Contact electricity
Proof of charge types on friction rods with a glow lamp
Proof of charge types on foils and sheets with a glow lamp
Contact electricity between electricity clear adhesive tape and metal
Contact electricity generation by friction

Forces acting between charges
Forces acting between charges on friction rods
Forces acting on a charged pendulum pair
Model of an electroscope
Principle of electroscope operation

Electric induction - Effect of charges on neutral bodies
Induction phenimena with conductors and non-conductors
Electrostatic charging of hair
Forces caused by induction
Induction phenomena on a pointer
Electric induction on a pendulum pair
Electric induction in a water stream

Electric induction - Effect of charges on a close electroscope
Induction phenomena on an electroscope caused by friction rods
Discharge of an induced charge on an electroscope
Induction phenomena on an electroscope caused by a foil

Charge stores, faraday cup
Conductive bodies as charges stores
Location of charges on a Faraday cup
Proof of charges on a Faraday cup
Electrostatic forces on a Faraday cup

Electrostatic interaction
Electrostatic forces between a friction rod and pendulum
Charge transport by a pendulum

Insulators and conductors
Charges on insulators
Proof of conductivity with a glow lamp
Proof of conductivity with an electroscope
Influence of a flame on electrically charged bodies
Influencing the electroscope charge by means of a flame
Point discharge

3.2 Electric Fields

Electrical charges
Separation of charge(contact and friction electricity)
Charge distribution on electrostatically charged bodies

Electric fields
Recording equipotential lines
Electric induction
Field investigations on a Faraday cup
Transfer of electrical charges on Faraday cups

Capacitors
Voltage change during charging of a Faraday cup with water drops
Capacitances of capacitors (relative determination)
Laws of the plate capacitor
Capacitance of bodies with respect to the environment (Conductor balls and other bodies)

Further experiments on charge transport
Charge transport by a pendulum
Charge transport by poor conductors

3.3 Magnetic Forces and Fields

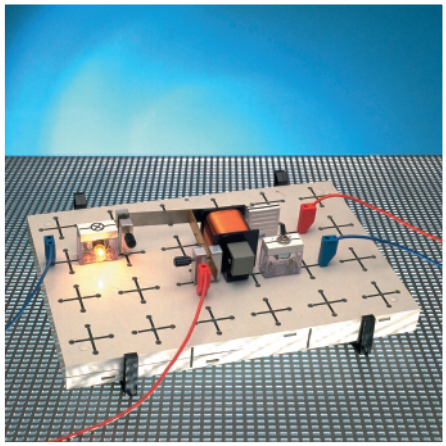
Effects of magnetic forces
Magnetic and non-magnetic materials
Positions of the magnetic poles of bar magnets
Polarity of magnets

Magnetic induction
Magnetization
Disassembling magnets
Putting magnets together

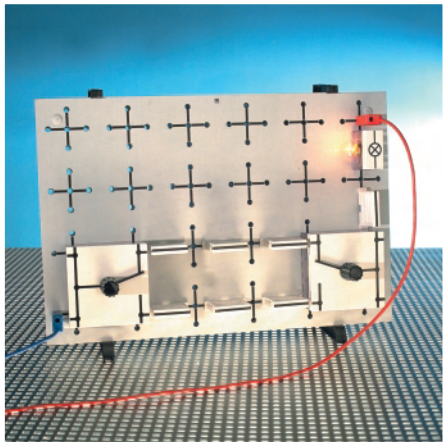
Magnetic fields
Demonstration a magnetic field with iron filings
Lines of force of a bar magnet
Experiments on a model of the earth's magnetic field
Lines of force of a horseshoe magnet
Lines of force of attracting magnetic poles
Lines of force of repelling magnetic poles

Basic Electric Circuits
Electromagnetism and Induction
Generators and Motors · Electrochemistry

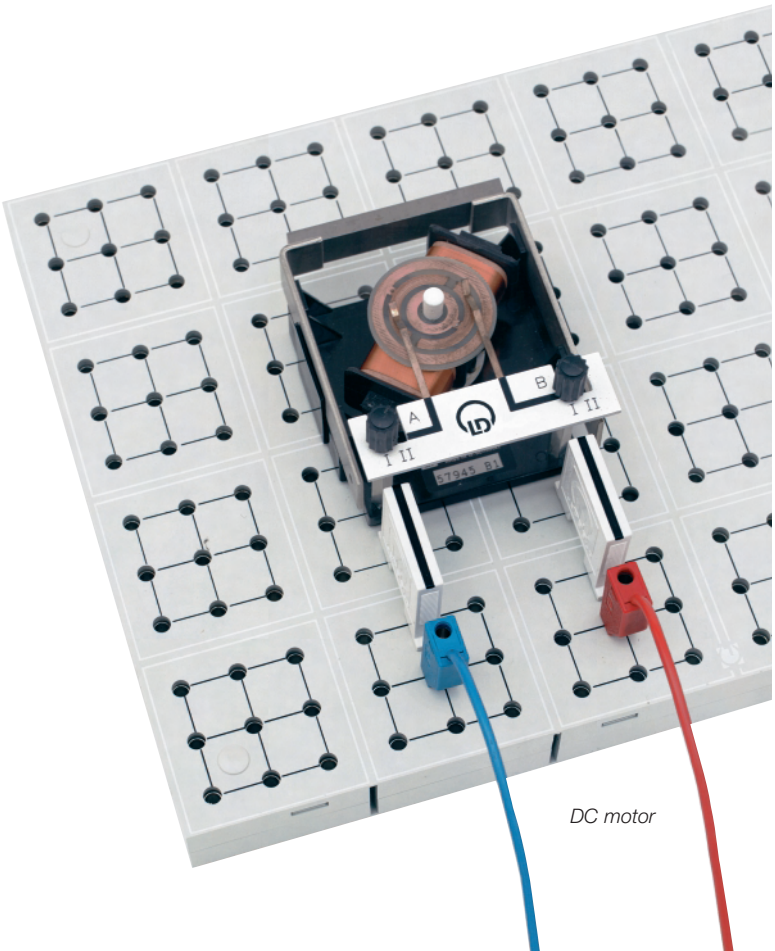
TOPIC GROUP	MANUAL	REQUIRED EQUIPMENT				
3.4 Basic Electric Circuits	588 332	Basic Electrics 588 871	Electricity 1 588 875			
3.5 Electromagnetism and Induction	588 342	Basic Electrics 588 871	Electricity 1 588 875	Electricity 2 588 876		
3.6 Generators and Motors	588 352	Basic Electrics 588 871		Electricity 2 588 876	Electricity 3 588 877	
3.7 Electrochemistry	588 402					Electro-chemistry 588 873



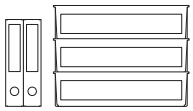
Relay



Switching over



DC motor



3.4 Basic Electric Circuits

Circit and switches
The simple circuit
Conductors and non-conductors (insulators)
Switching over
Two-way circuit
AND gate, OR gate

Electrical measuring methods
Measuring current - current in a simple circuit
Measuring voltage - voltages in a simple circuit

Ohmic resistor
Ohm's law
How a wire's resistance depends on ist material, length and cross-section
Voltage distribution in a current-carrying wire (potentiometer)
Connecting resistors in series
Connecting resistors in parallel

Voltage sources
Connecting monocells in series and in parallel
Terminal voltage and internal resistance of a voltage source

Electrical application circuits
Self-heating and temperature sensitivity in wire-wound resistors
Model of a fuse
Bimetallic-element switches (model of a fire alarm)
Model of a thermostat
Power of and work done by an electrical current

3.5 Electromagnetism and Induction

Electromagnetism
Magnetic effect of electric current
Current carrying conductor in a magnetic field
Magnetic field of a coil

Electromagnetic applications
Electromagnet
Model of a magnetic circuit breaker
Model of a moving-iron instrument
Model of an electromagnetic relay
Model of a buzzer (doorbell)
Model of a loudspeaker

Induction
Electromagnetic induction with bar magnet an a coil
Electromagnetic induction with two coils

Transformer
Voltage transformation
Current transformation

Technical applications of induction
Self-induction of a coil (model of an induction coil)
Model of an AC generator
Model of a synchronous motor

Coil and capacitor
DC and AC resistance of a coil I (observation experiment)
DC and AC resistance of a coil II (measuring experiment)
Capacitor in a DC circuit
Capacitor in an AC circuit

3.6 Generators and Motors

Basic experiments
Magnetic field of the stator
Magnetic field of the rotor
Rotors in the magnetic field of the stator
Electromagnetic induction with bar magnet and coil

Generators
Dynamo
Principle of the universal generator
Operating characteristics of the universal generator
Power plant generator
AC/DC generator with electromagnetic stator

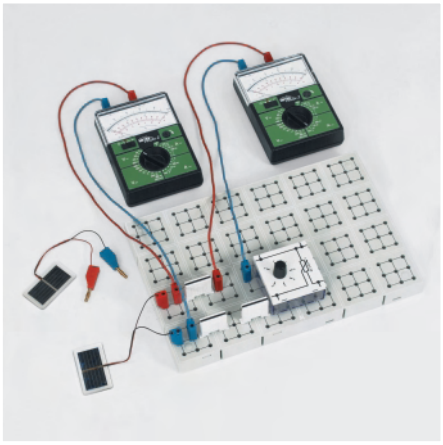
Electric motors
Working principle of the DC motor
Power consumption of the DC motor
DC motor with electromagnetic stator
Universal shunt-wound motor
Principle of the universal series-wound motor
Power consumption of the universal series-wound motor
Synchronous motor
Electronic motor

3.7 Electrochemistry

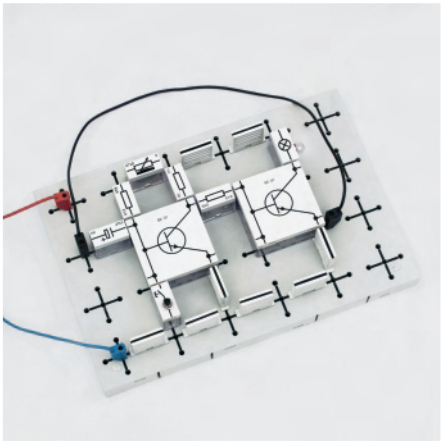
Basic experiments
Conductivity of aqueous solutions (electrolytes)
Observing a liquid conducting a current (electrolysis)
Relationship between current and voltage in an electrolyte
How an electrolyte's resistance depends on the electrode gap
Electroplating
Voltaic cells
Lead storage battery (accumulator)

Basic Electronic Circuits
Transistor Applications
Opto Electronics

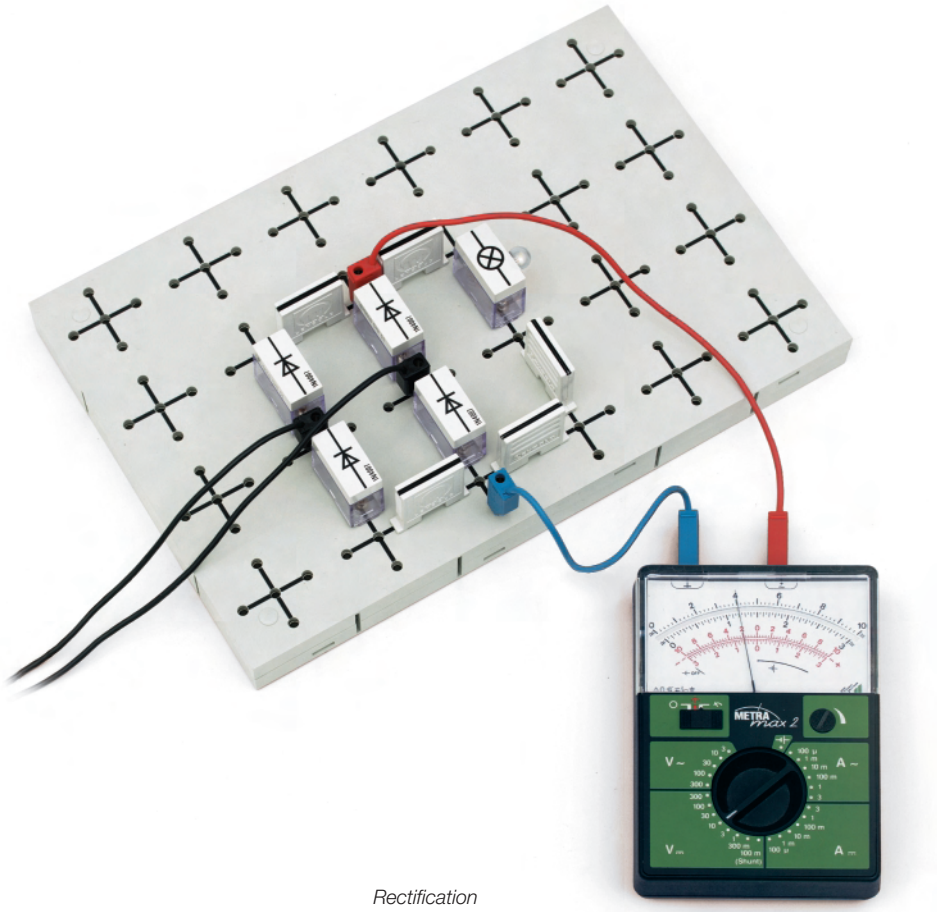
TOPIC GROUP	MANUAL	REQUIRED EQUIPMENT				
4.1 Basic Electronic Circuits	588 422	Basic Electrics 588 871		Electronics 1 588 881		
4.2 Transistor Applications	588 022	Basic Electrics 588 871	Electrics 2 588 876	Electronics 1 588 881	Electronics 2 588 882	
4.3 Opto Electronics	588 032	Basic Electrics 588 871		Electronics 1 588 881	Electronics 2 588 882	Electronics 3 588 883



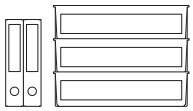
Characteristics of solar cells



Delay switch



Rectification



4.1 Basic Electronic Circuits

Special resistors
Temperature-dependent resistor NTC
Light-dependent resistor LDR (photoresistor)
Light controlled relay

Diodes
Characteristic of a diode
Half-wave rectification
Full-wave rectification
Measuring peak voltages, voltage doubling
Light emitting diodes
Polarity tester with diodes
Series connection of diodes
Characteristic of a Z-diode
Overload protection using a Z diode

Transistors
Diode paths with transistors, testing circuit with light emitting diodes
Transfer characteristic of a transistor
Transistor circuit I: voltage control
Base voltage division
Transistor circuit II: current control
Light controlled transistor I: light barrier
Light controlled transistor II: twilight switch
Delay switch
Testing for hum

4.2 Transistor Applications

Diode circuits
Zero-point suppression with a Z-diode
Using diodes to protect against overvoltage and reverse polarity
Suppressing induction voltages with a diode (free-wheeling diode)
Smoothing pulsating DC voltages with capacitors
Constant current source - charging capacitors with a constant current

Voltage stabilizer circuit
Series voltage regulation
Voltage stabilizer circuit
Basic experiments with flip-flops
Bistable flip-flop as a memory element
Monostable flip-flop as a time-delay swich
Astable flip-flop (astable multivibrator)
Generating sounds with an astable multivibrator (police siren, birdsong)
Miniature organ I - musical scale on a pencil line
Extra experiment: miniature organ II - making and tuning a small electronic keyboard

Amplifying circuits
Amplifying a voltage pulse
Setting and stabilizing the working-point of a single-stage microphone amplifier
Two-stage microphone amplifier
Medium-wave receiver, single-stage and two-stage
Basic experiment: amplifier for voltage differential (difference amplifier)
Sensitive light meter with a difference amplifier
Determining the DC voltage gain (push-pull gain) of a difference ampifier
Touch-contact switch, moisture and filling-level indicator
Current gain factors

Feedback and oscillators
Electronic motor
Acoustic feedback
Meissner circuit
Three-point oscillator
Phase shift oscillator
Wien oscillator

4.3 Opto Electronics

Experiments with light waveguides
Demonstration light conduction in light waveguides
Attenuation in the light waveguide

Light emitting diodes
The light emitting diode in the circuit:
reverse bias and forward bias behavior
Characteristics of light emitting diodes

Voltage stabilizer circuit
Basic circuit with a photodiode

Solar cells
Forward and reverse direction of a solar cell
Internal resistance of a solar cell
Output and power characteristics of a solar cell
No-load voltage of a solar cell
Short-circuit current of a solar cell
Connecting solar cells in series
Connecting solar cells in parallel
Conversion light energy into motion

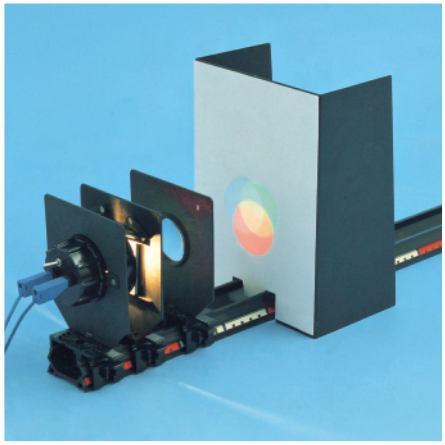
Phototransistors
Photo transistor with base connection, basic experiments
Photo transistor equivalent circuit
Current gain of the photo transistor

Forked light barrier
Forked light barrier with following transistor

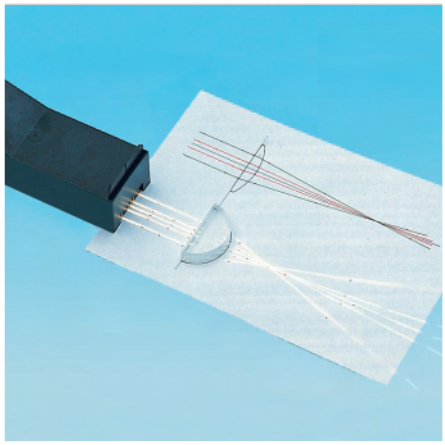
Light transmitters and receivers
Transmitting sound with the light waveguide
Transmitting music and speech with the light waveguide

Geometrical Optics with the Raybox
Geometrical Optics on the Precision Metal Rail
Colour Mixing

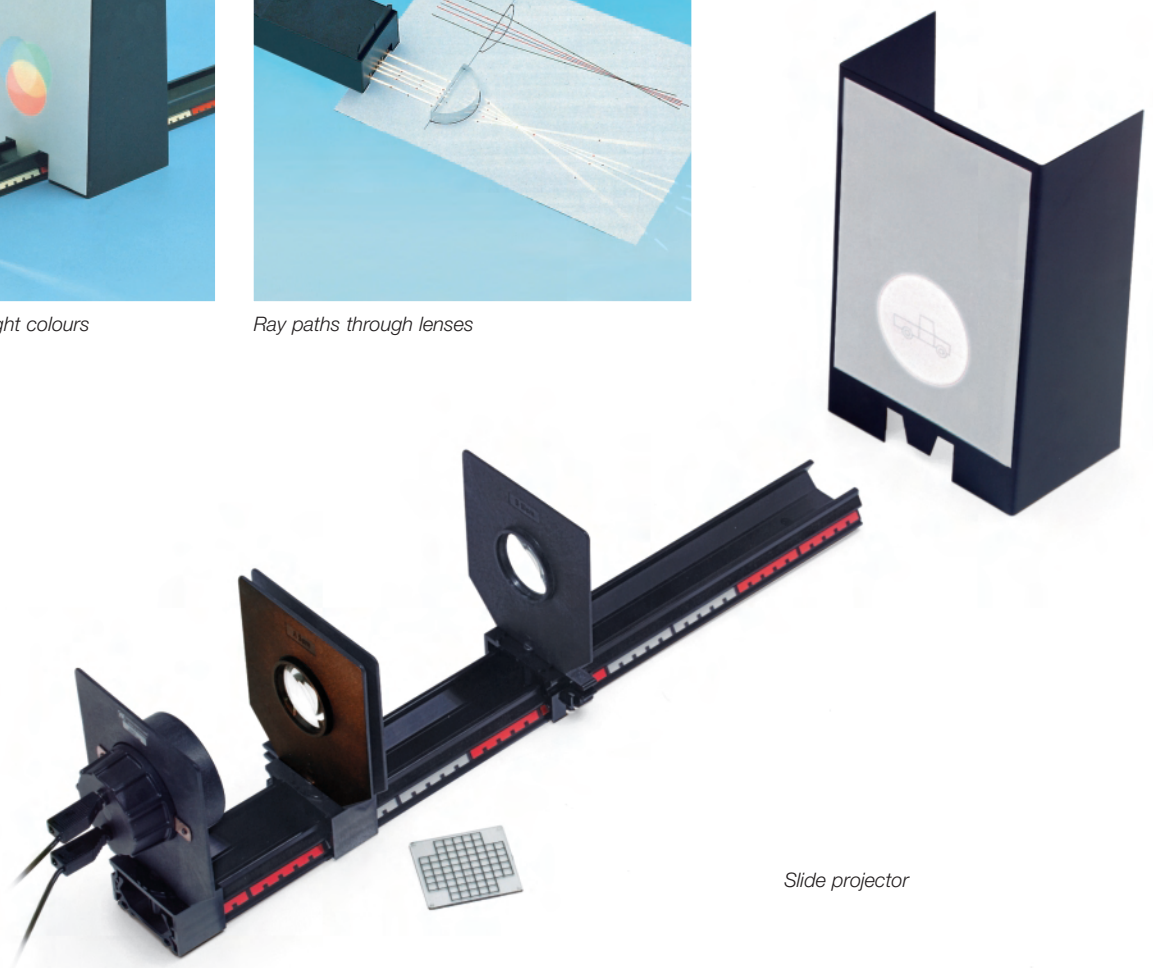
TOPIC GROUP	MANUAL	REQUIRED EQUIPMENT				
5.1 Geometrical Optics with the Raybox	588 202	Optics Raybox 588 845				
5.2 Geometrical Optics on the Precision Metal Rail	588 212	Basic Optics 588 840	Optics 1 588 841			
5.3 Colour Mixing	588 222	Basic Optics 588 840		Optics 2 588 842		



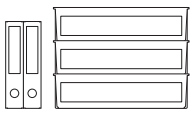
Additive mixing of three light colours



Ray paths through lenses



Slide projector



5.1 Geometrical Optics with the Raybox

Beginning experiments on light
The raybox
Propagation of light
Can light pass through all matter?
Shadows

Reflection at mirrors
Reflections at a plane morror
Mirror image at a plane mirror
Ray paths in a concave mirror
Focal length of a convex mirror

Refraction
Refraction of light at a semicircular body I
Refraction of light at a semicircular body II
Total reflection
Refraction at a plane-parallel Plate
Refraction in different media at a rectangular cell
Refraction in different media at a semicircular cell
Diviating prism
Inverting prism
Dispersion of white light with a prism

Lenses
Ray paths through a convex lens
Ray construction with a biconvex lens
Spherical aberration of a lens
Ray paths through a concave lens
Ray construction with a concave lens
The human eye
Visual error and eye correction

5.2 Geometrical Optics on the Precision Metal Rail

Basic experiments
Propagation of light
Shadows
Pinhole camera
Illuminance
Luminous intensity
Light collectors

Light and shadow in nature
Day and night
The seasons
Phases of the moon
Lunar and solar eclipse

Reflection at mirrors
Reflection at the plane mirror
Locations of images in a plane mirror
Mirror images at the plane mirror
Ray paths for different types of mirrors
Properties of a concave mirror
Properties of a convex mirror
Focal length law of a concave mirror
Images at the concave mirror
Images at the convex mirror

Refracion of light
Refraction of light at a semicircular body I
Refraction of light at a semicircular body II
Total reflection
Refraction at a plane-parallel plate
Refraction in different media at a rectangular cell and a plane-parallel plate
Refraction in different media for a semicircular cell and a semicircular body
Deviating prism
Inverting prism

Dispersing and recombining of colours
Dispersion of white light with a prism
Recombining spectral colours with a lens

Lenses/lens aberration
Ray path through a convex lens
Constructional rays of a convex lens
Images of convex lenses
The image formula
Determining the focal length of a convex lens by means of autocollimation
Ray path through a concave lens
Ray paths of lens combinations
Spherical aberration of lenses
Cushion and barrel distortion

Combinations of lenses
Focal lengths of lens systems

Optical instruments for enlarging the field of view
Magnification with a magnifier
The microscope
Changing the magnification of a microscope
Telescope models
Magnification in a terrestial telescope
Magnification in an astronomical telescope

Optical instruments and eye
The camera
Depth of field of a camera
The slide projector
The human eye
Vision errors and vision correction
Optical illusions

5.3 Colour Mixing

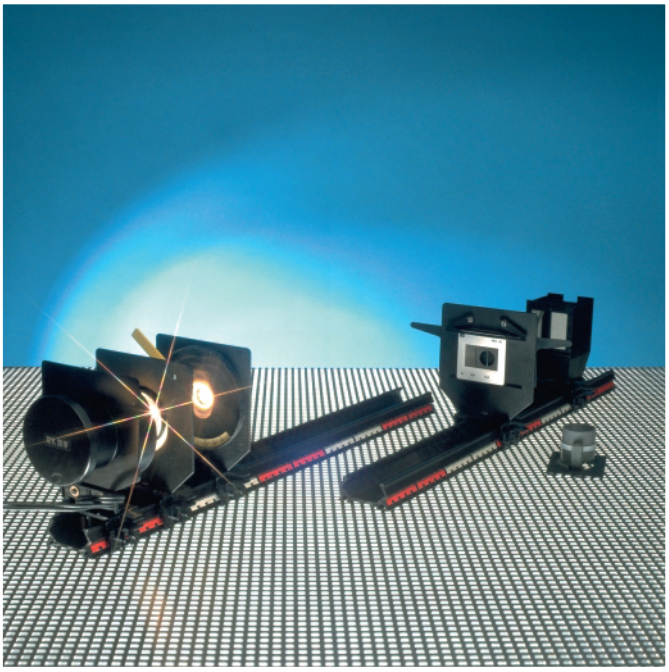
Investigation of light paths through a prism
Path of light through a prism
Light paths through a prism in different positions
Deflection in the prism
Minimum and maximum deflection

Spectral colours
Dispersion of white light with a prism
Chromatic aberrations of images
Investigating the spectrum colours
Spectra for different slits
Colour fringing at edges
Edges spectra

Colour mixing
Recombining a spectrum
Light colours and object colours
Additive mixing of two light colours
Additive mixing of three light colours
Subractive colour mixing

Diffraction Polarisation

TOPIC GROUP	MANUAL	REQUIRED EQUIPMENT				
5.4 Diffraction	589 252 589 262	Basic Optics 588 840			Optics 3 588 843	
5.5 Polarization	589 272	Basic Optics 588 840				Optics 4 588 844



Set-ups for diffraction experiments

TOPICS

5.4 Diffraction

Diffraction at diffraction objects
Diffraction at a half plane
Diffraction at a slit
Diffraction at double slits
Diffraction at multiple slits
Diffraction at gratings
Conditions for coherence with lamp light

Diffraction at complementary diaphragms (Babinet principle)
Slit and wire
Holes and objects
Complementary crossed gratings

Resolution capability
Resolution capability of the eye

Two-beam Interference
Fresnel's double mirror experiment
Fresnel's biprism experiment
Young's double slit experiment
Newton's rings

5.5 Polarization

Polarization filters
Using polarization filters (introductory experiments)
Malus' law

Strain optical double refraction (optical anisotropy)
Chromatic polarization
Double refraction in various materials
Strain double refraction on plexiglass models

Polarization resulting from reflection and refraction
Polarization resulting from reflection
Polarization resulting from refraction
Brewster's law

Polarization resulting from scattering
Tyndall-Effekt in einer Emulsion

Optical activity
Polarimetry (saccharimetry) and rotary dispersion

TOPIC GROUP

6.1 Radioactivity

MANUAL

588 482

REQUIRED EQUIPMENT

Radioactivity 1

588 855

TOPICS

6.1 Radioactivity

Investigating the Geiger-Müller counter tube
Detecting the radiation emitted by a radioactive gas mantle
Behavior of a Geiger-Müller counter tube with no radiation source
Investigating the radiotransparency or the end window and housing of the end-window counter
Reducing the size of the end window of a counter tube
Counting losses in a end-window counter

Radioactive radiation
Radiation from an unscreened source
Radiation from a radiation source screened at the sides
Using reflectors with an unscreened radiation source
Investigating the radiation beam of a radium preparation

Statistics of radioactive decay
The effect of the distance between the radiation source and the end-window counter on the pulse rate
Investigating the variations in pulse rate measurements
Statistical error of a single measurement
Statistical investigation of background radiation

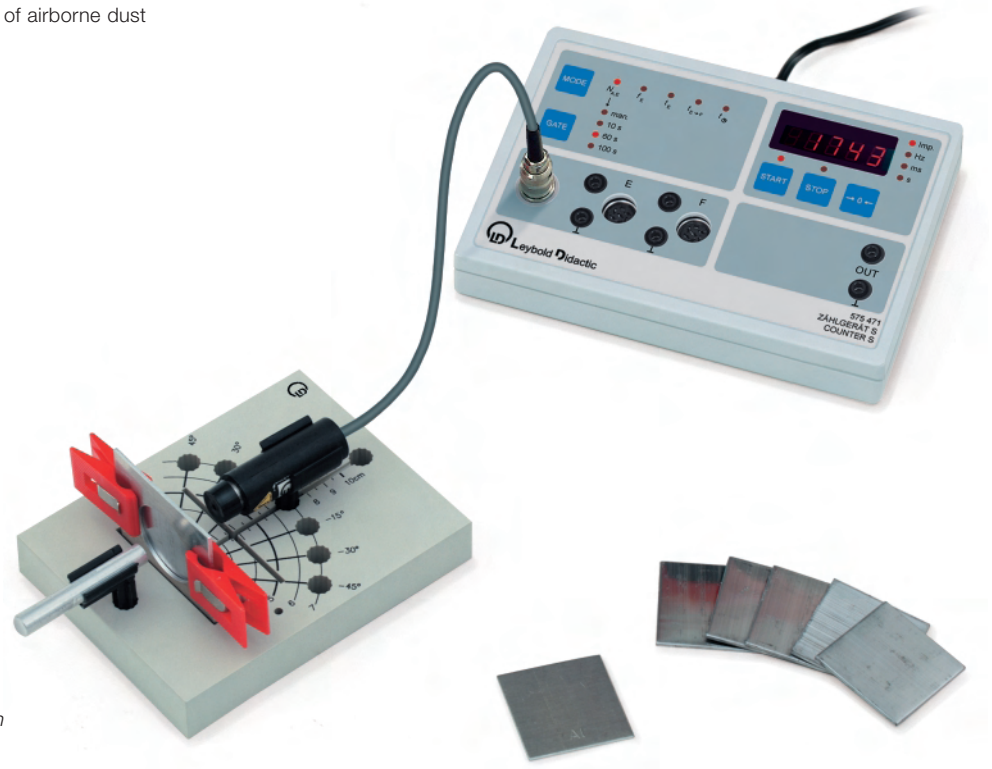
Investigating different sources of radiation
Pulse rate measurements for different masses of thorium
Investigating potassium sulphate
Investigating Brazil nut ash
Investigating bricks
Radioactivity decay of airborne dust

Distinguishing α, β and γ radiations
The effect of paper on the pulse rate when placed between a mixed radiation source and the end-window counter
Testing for different radiation types using paper filters

β radiation
Testing for different radiation types using a magnetic field
Deflection β radiation with a magnetic field
Scattering of β radiation
Backscattering of β particles

Screening γ radioation
Screening γ radiation with different materials
Screening γ rays with lead layers of different thicknesses

Technical applications of radioactive radiation
Monitoring contents with β radiation (radiographic method)
Measuring layer thicknesses with β rays (radiographic method)
Monitoring filling levels with γ rays (radiographic method)
Testing for cavities in a plastic-coated lead slide (radiographic methode)
Measuring layer thicknesses with β rays (backscatter method)

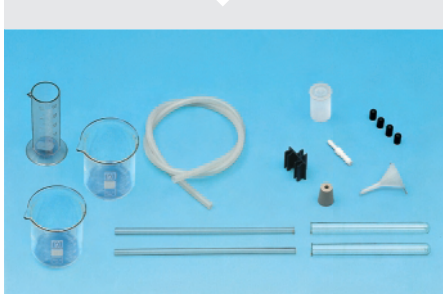


Screening γradiation

List of content

588 801 Basic Mechanics Heat 1

1 Double scale 340 82
1 Universal clamp 666 555
1 Stand rod, 25 cm 301 26
2 Stand rods ,50 cm 301 27
1 Double clamp 301 09
1 Multi-clamp 666 615
1 Metal plate 200 65 559
3 Support clips, for plugging in 314 04
2 Stand bases, MF 301 21
2 Support blocks 301 25
1 Pair of pointers 301 29
1 Universal pencil 309 45
1 SET of 6 leads, 50 g ea. 340 85
1 Aluminum block 362 32
1 Tape measure 1.5 m 311 78
1 Cord 20 m 200 70 322

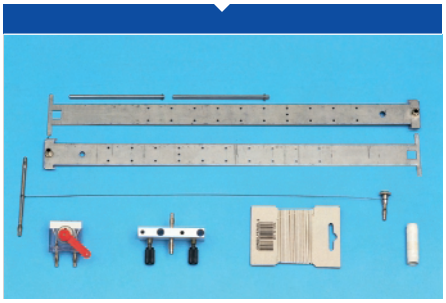


588 802 Basic Mechanics Heat 2

1 Beaker, 250 ml 664 130
1 Measuring cylinder, 100 ml 590 08
1 Plastic beaker, 250 ml 664 123
1 Silicone tubing, 1 m 667 194
2 Plastic tubes, 25 cm 200 69 648
1 Round tin 200 69 647
1 Double pipe support 200 69 370
1 Connector 665 226
4 Cap 200 69 649
1 Mini-funnel 309 83
1 Stopper with hole 200 69 304
2 Test tube .....from 664 042

588 811 Mechanics 1

1 Vernier calliper 311 52
1 Plastic tube, 250 x 25 mm 665 240
1 Inclined plane S 341 221
1 Leaf spring 352 051
2 Pulleys d=100 mm 340 921
2 Pulley bridge 340 930
2 Balance pans with stirrup 342 47
1 Dynamometer 1.5 N 314 01
1 Dynamometer 3.0 N 314 02
1 Helical spring 0.25 N/cm 352 08
1 Helical spring 0.1 N/cm 352 07
1 Set of wheights 1-50 g 590 27
1 Lever with pointer 340 831
2 Pulleys d=50 mm 340 911
1 O-rings, rubber 10 pcs. 340 90
1 Coupling plug 340 89
1 Plug-in axle 340 811
1 Load hook 340 87
1 Pressure probe 362 301
1 Capillary apparatus 362 26
1 Lead shot 100 g 362 351
1 Stopper without hole 667 257

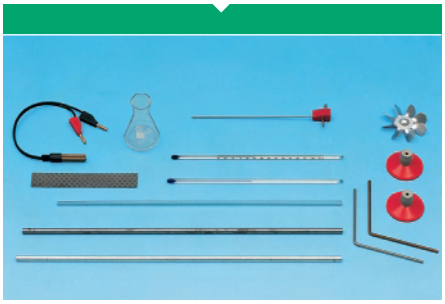


588 812 Mechanics 2

1 Pair of bar pendulums with axles 346 03
1 Torsion wire with bar 346 02
1 Perlon Yarn 118 05 103
1 Rubber cord 200 66 629
1 Clamping block 346 05
1 STE Motor with rocker 579 42

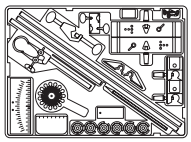
588 813 Mechanics 3

1 Precision metal rail, 1 m 460 81
1 Set of acceleration masses 337 04
1 Additional mass 1, 100 g 337 05
1 Trolley 1, 85 g 337 00
1 Time recorder 337 18
1 Single pulley on rider 337 14
1 Stepped support block 337 06



588 831 Heat

1 Immersion heater, 12 V/11W 597 48
1 Erlenmeyer-flask, 50 ml 664 248
1 Pointer for linear expansion 381 331
1 Stirring thermometer, -30 to +110°C 382 21
1 Stirring thermometer, ungraduated 382 20
1 Blade wheel 387 79
1 Pair of radiation probes 384 531
1 Heat conducting rods, Fe/Cu 384 501
1 Al-tube, 44 cm long 381 332
1 Fe-Tube, 44 cm long 381 333
1 Ascending tube, 40 cm 381 10
1 Bimetallic strip 381 311



List of content

588 860 Magnetism 1

1 Hemisphere for earth's magnetism.....510 56
2 Bar magnets.....510 50
1 Shaker for iron fillings 514 72
1 Storage bottle with iron fillings 514 73
1 Direction-finding compass 510 55
1 Pair of plotting compasses 510 53
1 Set of 4 magnetizable rods.....510 54
1 Pair of iron yokes.....510 60

588 73 Electrostatics 1

1 Set of dielectrics, 300 mm x 300 mm.....544 25
1 Tubular glow lamp 110 V.....from 505 41
1 Pair of plastic clips 200 67 942
1 Pair of electrostatic pendulums 200 67 941
1 Induction plate, 40 x 80 mm.....542 51
2 Polyethylene friction foils.....200 70 750
2 Pairs of friction rods,
acrylic glass/PVC.....541 00
1 Faraday's cup 546 12
1 Electroskope S 540 08

588 74 Elektrostatics 2

1 Faraday's cup 546 12
1 Pair of metal plates,
290 x 290 mm each, with 4-mm plug
connections each and spacers.....544 24
1 Electrolytic tank,
with 2 rod-, 2 disc- and
1 ring-form electrodes 545 09
1 Set of 3 metal spheres,
25/30/35 mm dia.,
with attachable insulating handle 543 00
1 Crocodile clip, polished .....from 501 861
2 Plugs with 4-mm side and
top connections .....from 501 564
1 Coupling plugs 4 mm 340 89
1 Two-way adapter 4 mm .....from 501 641
1 Knitting needle .....from 510 32
1 Metal plate, 40 mm x 40 mm,
with insulating handle 542 52
1 Induction plate, 40 mm x 80 mm 542 51
1 Metal coated hollow sphere.....543 01

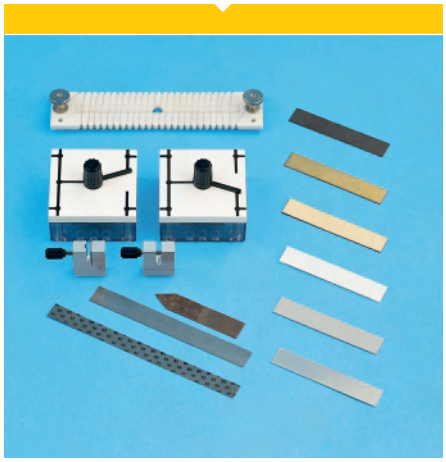
588 873 Electrochemistry 1

2 Copper electrodes, 76 x 40 mm ....from 591 53
1 Zinc electrode, 76 x 40 mm .....from 591 54
1 Iron electrode, 76 x 40 mm .....from 591 55
1 Electrolysis cell 591 51

588 871 Basic Electricity/Electronics

1 Plug-in board A4 .....576 74
1 Board holders.....576 77
1 Set of 10 bridging plugs 501 48
2 Coupling plugs 340 89
2 Croc-clips, polished.....from 501 861
1 STE Resistor, 47 W 577 28
2 STE Resistors, 100 W 577 32
2 STE Lamp holders, E10 .....579 05
1 STE Toggle switch.....579 13
2 STE Monocell holders.....576 86

List of content



588 875 Electricity 1

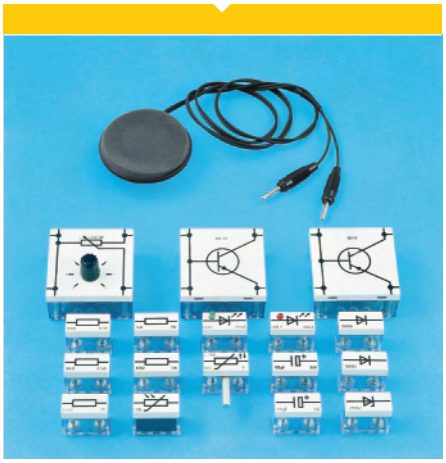
2 STE Changeover switches, single-pole...582 81
1 Wire wrapping plate ...567 18
1 Set of conductors/insulators...567 06
1 Bimetallic strip ...381 311
1 Leaf spring with contact strip ...579 332
2 Plug-in holders ...579 331

588 876 Electricity 2

1 Bar magnet ...510 50
1 U-core, demountable...593 21
1 Coil, 500 turns...590 83
1 Coil, 1000 turns...590 84
1 Set of 4 magneticeable rods...510 54
1 Glow lamp, 115 V...505 36
1 Rotary support for bar magnet ...510 51
1 Plotting compass ...from 510 53

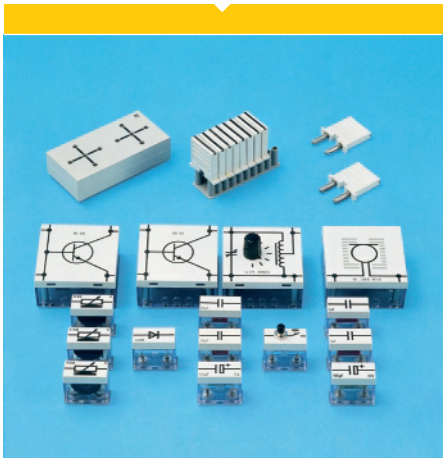
588 877 Electricity 3

1 STE Stator with pole shoes ...579 45
1 STE Coil rotor...579 46
1 STE Brush yoke ...579 47
1 STE Magneto inductor...579 48



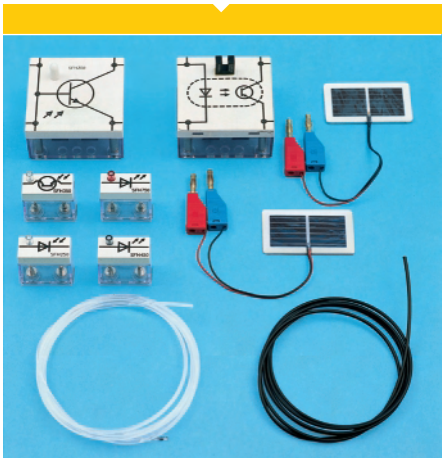
588 881 Electronics 1

1 STE Potentiometer , 220 W...577 90
1 Earphone...579 29
1 STE Transistor BD 137 ...578 67
1 STE Transistor BD 138 ...578 68
2 STE Si-diodes 1 N4007...578 51
1 STE Z-diode ZPD 6,2 ...578 55
1 STE Capacitor 100 m F...578 39
1 STE Capacitor 470 m F...578 40
1 STE Light-emitting diodes LED green.....578 57
1 STE Light-emitting diodes LED red.....578 48
1 STE NTC-Resistor 2,2 kW ...578 05
1 STE Photoresistor LDR 05...578 02
1 STE Resistor, 470 W ...577 40
1 STE Resistor, 1 kW...577 44
1 STE Resistor, 4,7 kW...577 52
1 STE Resistor, 10 kW...577 56
1 STE Resistor, 47 kW...577 64



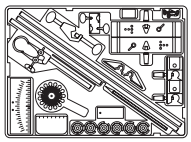
588 882 Electronics 2

1 board section ...576 71
1 Set of 10 bridging plugs ...510 48
1 STE Microphone...579 27
2 STE Capacitors, 1 µF ...578 35
1 STE Capacitor, 470 µF ...578 40
1 STE Medium-wave LC oscillating circuit...578 94
1 STE Contact (NO)...579 10
2 STE Capacitors, 0,1 µF ...578 31
1 STE Capacitor, 100 µF ...578 39
1 STE Ge-diode AA 118...578 50
1 STE Variable resistor, 100 kW ...577 83
1 STE Variable resistor, 47 kW ...577 82
1 STE Variable resistor, 10 kW ...577 80
1 STE Transistor BD 137 ...578 67
1 STE Transistor BC 550 ...578 69



588 883 Electronics 3

1 STE photo-transistors for OWG...578 613
1 STE Forked light barrier...578 835
2 STE Solar cells ...578 622
1 Pair of optical waveguides...579 44
1 STE infrared diode for OWG...578 482
1 STE photodiode for OWG ...578 612
1 STE light ermitting diode for OWG...578 481



List of content

588 845 Optics with the raybox

1 Raybox 12 V, 20 W 459 091
1 Combined mirror model.....459 41
1 Plano-concave lens 459 50
1 Plano-convex lens 459 48
1 Semicircular body.....459 45
1 Right-angled prism 459 46
1 Trapezoidal body 459 44
1 Semicircular cell.....459 52
1 Rectangular cell.....459 51
1 Disk with angular scale.....459 40

588 840 Basic Optics

1 Set of 2 slit diaphragms.....461 62
1 Measuring tape, 1.5 m 311 78
1 Optics table.....459 15
1 Extension pin.....309 00 441
2 Candle holders 459 31
5 Clamp riders.....460 95
1 Lens A, f = +50 mm 459 60
1 Lens B, f = +100 mm 459 62
1 Lens H, f = +300 mm.....459 64
1 Halogen optical lamp, 12V/20W 459 031
1 Diaphragm and slide holder.....459 33
1 Precision metal rail 460 82

588 841 Optics 1

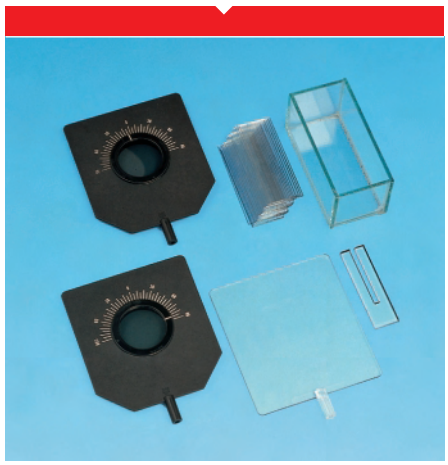
1 Set of 12 Transparencies »Optical illusions«.....461 68
1 Set 4 different diaphragms 461 63
1 Rectangular cell.....459 51
1 Semicircular cell.....459 52
1 Lens model, plan-convex 459 48
1 Lens model, plan-concave 459 50
1 Rectangular prism 459 46
1 Earth-moon model 459 39
1 Trapezoidal body 459 44
1 Plane mirror.....459 38
1 Semicircular body.....459 45
1 Convex-concave mirror 459 71
1 Plate holder 459 30
1 Transparent screen.....459 24
1 Lens E, f = -100 mm 459 68
1 Combined mirror model.....459 41
1 Set of 2 transparencies 461 66
1 Set of 4 hole diaphragms 461 64

588 842 Optics 2

1 Lamp, threefold 459 045
1 Filter, threefold, red/green/blue 467 97
1 Colour filter set, red/green/blue 467 95
1 Colour filter set, magenta/cyan/yellow 467 96
1 Acrylic glass prism.....465 20

588 843 Optics 3

1 Magazine box for 30 slides.....442 89
1 Diaphragm with 3 single slits 469 91
1 Diaphragm with 4 double slits 469 84
1 Diaphragm with 3 double slits 469 85
1 Diaphragm with multiple slits 469 86
1 Diaphragm with 3 gratings.....469 87
1 Diaphragm with 2 wire-mesh gratings 469 88
1 Diaphragm with 3 hole-object pairs 469 89
1 Diaphragm with slit and wire.....469 90
1 Colour filter, red 200 25 265
1 Precision metal rail 460 82
1 Mirror box.....459 17
1 Measuring magnifier 459 19
1 Adjustable slit 471 71



588 844 Optics 4

2 Polarization filters.....472 38
1 Set of object frames 662 093
1 Glass tank 477 02
1 Photo-elastic object.....471 94
1 Acrylic glass screen.....459 23

588 855 Radioactivity

1 Counter tube holder
1 Preparation holder
1 Magazine box
for absorbers and diaphragms;
dimensions: 50 mm x 50 mm
8 Lead slides
3 Lead diaphragm
4 Aluminium slides
2 Steel slides
1 Tin slide
2 Plastic slides
1 Lacquered lead slide
with two different lacquer thicknesses
1 Acetate film, 300 x 300 mm
1 RAD plug-in board
3 Clamps
2 Round magnets in holders
1 Plastic tube, 150 mm long
1 Aluminium frame, 70 mm x 70 mm
1 Incandescent gas hood
2 Ballons
1 Can with Brazil nut ash
1 Bottle with potassium sulphate, 50 g
2 Metal plates
1 Bottle with lead shot, 100 g
1 Set of 10 plastic bags
1 Preparation mock-up
2 Magnet holding pins, 80 mm long
2 Tube holders

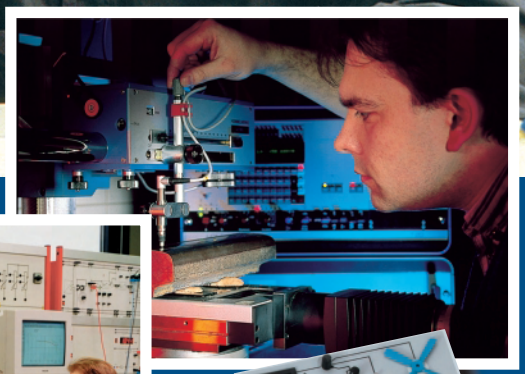
Accessories and cnsumable materials

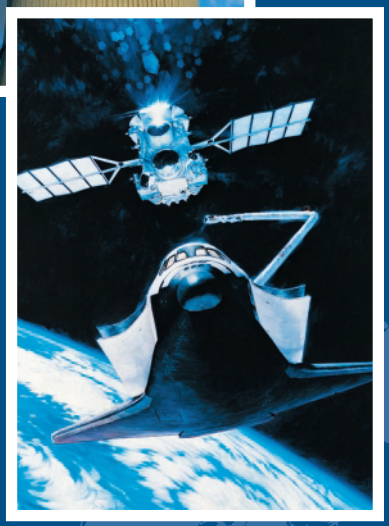
Description	Topic group / Cat. No.	1.1	1.2	1.3	1.4	2.1	3.1	3.2	3.3	3.4	3.5	3.6.	3.7	4.1	4.2	4.3	5.1	5.2	5.3	5.4	5.5	6.1	completely minima
Single pan balance	315 07	1*				1*																	1
Electronic balance	667 794	1*				1*																	
Stop-clock	313 07	1	1	1		1									1								1
Scissors	667 017	1	1			1				1	1												1
Colouring soluble	309 42	1				1																	1
Overflow fressel	362 04	(1)																					(1)
Writing pin	309 05 060			(1)																			(1)
Roll metallizid paper	346 06			(1)																			(1)
Crocodile clips, polish	200 72 828			(2)																			(2)
Pair magnets	510 48			(2)																			(2)
Burners and accessories, e.g.:																							
Bunsen burner	666 695					1*		1*															1
Safety gas hose	666 729					1*		1*															1
Cartridge burner	666 714					1*		1*															
Cartridges	666 715					1*		1*															
Wire gauze	666 685					1																	1
Stand ring with stem	302 68					1																	1
Electric tourch	450 651															1							1
Candle from	459 32									1								2					2
Precision metal rail 0,5 m	460 82																	1	1	1	1		1
Fresnel's mirror	471 04																			(1)			(1)
Apparatus for Newton's rings	471 08																			(1)			(1)
Fresnels Biprism	471 09																			(1)			(1)
Monocells from	503 11									2				1		2							2
Transformer 6V/12V	521 210			(1)*	1*	1*											1*	1*	1*	1*	1*		
Low-voltage power supply	521 230			(1)*	1*	1*				1*	1*		1*				1*	1*	1*	1*	1*		
AC/DC power supply	521 49			(1)*	1*	1*				1*	1*	1*	1*	1*	1*	1*	1*	1*	1*	1*	1*		1
AC/DC power supply 0..12 V	521 48			(1)*	1*	1*				1*	1*	1*	1*	1*	1*	1*	1*	1*	1*	1*	1*		
Power supply 450 V	522 27							1															1
Function generator	522 621			1								1				1							1
Metramax 2	531 100							1		2	2	2	2	2	2	2							2
Moving coil galvanometer	531 67										(1)	(1)											(1)
Electrometer amplifier	532 14							1															1
STE Capacitor 1 nF	578 25							1															1
STE Capacitor 10 nF	578 10							1															1
Connecting rod	532 16							1															1
Cabel				x				x		x	x	x	x	x	x	x		x	x	x	x		x
Insulated twin wire	501 47														(1)								(1)
Aerial amplifier	578 99														(1)								(1)
Loudspeaker with transformer	579 28														(1)								(1)
Micromotor	579 37															(1)							(1)
Incandescent lamps E 10:																							
2,5 V / 0,25 W from	505 11									2													2
4 V / 0,16 W from	505 07									1	1	1	1	1	2	1							2
12 V / 3 W from	505 08									2	1			2		1							2
3,7 V / 1,1 W from	505 06													1									1
6 V / 5 W	505 13													1									1
Resistance wire:																							
Constantan 0,35 mm	550 42									x	x												x
Chrom-nickel 0,25 mm	550 46									x													x
Chrom-nickel 0,35 mm	550 47									x													x
Iron 0,20 mm	550 51									x													x
End-window counter	559 01																					1	1
Counter S	575 471																					1	1
Ra 226 preparation	559 430																					1	1

Quantity for each group: (1) recommendable 1* alternative

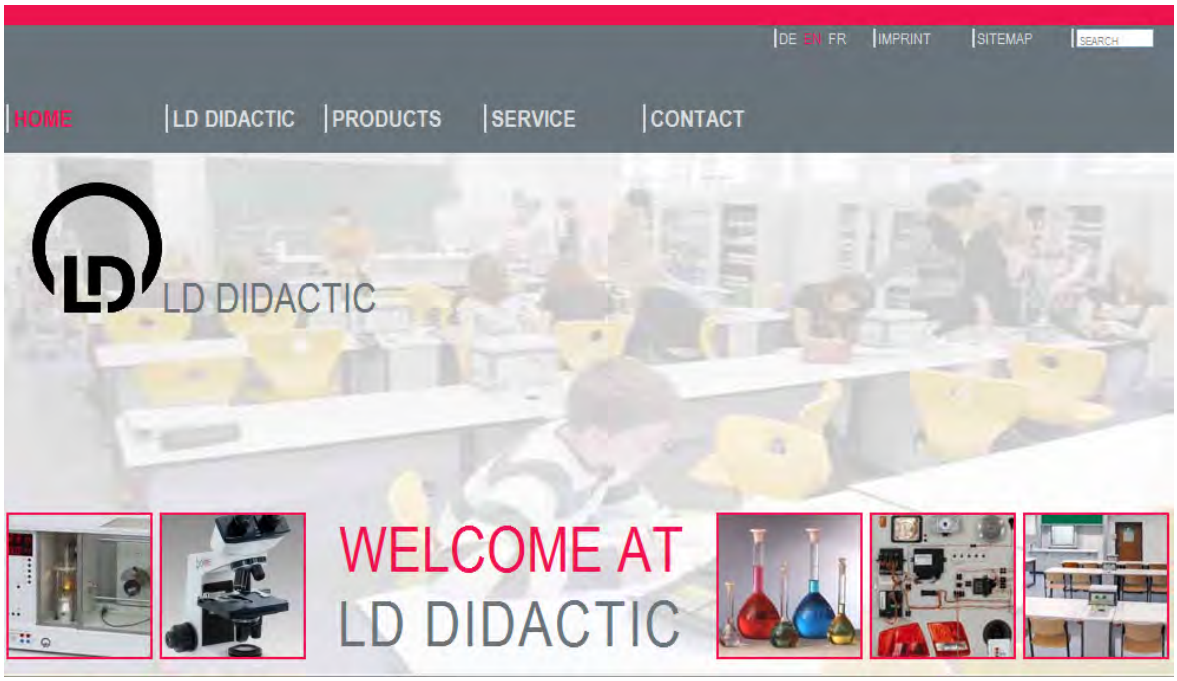
Complete teaching solutions from LD Didactic

Vocational Training · Chemistry · Biology · Physics





For further information on any of these products please do not hesitate to contact us.



www.ld-didactic.com

Meet the experts: the LD Didactic GmbH Website
Visit our website for the latest special offers and exciting information about our products. Plus, our Online Center is waiting to help you with technical questions.

+ 49 2233 604 - 0

LD DIDACTIC GMBH
Leyboldstraße 1
D – 50354 Huerth - Germany
+ 49 2233 604 - 222

info@ld-didactic.de

www.ld-didactic.com

588 801_STM_Physics_en–10.10