Construction box: Electric Current

Guidance for No. / Part 81937

Betzold

IMPORTANT – Read carefully before using. Keep safely for later use.

The electronic instructional construction set complies with the statutory requirements for the safety of toys in accordance with the Directive 2009/48/EC.

Warning Information for safe and correct use

Attention!

- The electronic instructional construction set is intended exclusively for use in the classroom.
- It is not suitable for children under the age of 8. This product contains a small magnet.Swallowed magnets can attract each other in the intestines and cause serious injury. Consult a doctor immediately if a magnet has been swallowed.
- The proper assembly must be checked by an adult before use.
- Children must only use the electronic instructional construction set under the supervision of an adult.
- The construction set is not suitable for children under the age of 3 due to small parts which can be swallowed. Risk of chocking!
- Do not connect the components of the electronic instructional construction set to power sockets!
- Do not operate the components with a voltage greater than 9 volts!
- In some experiments components may become hot. Only touch these after they have cooled down.
- Avoid the direct connection of the two battery poles without a device connected between them, otherwise a short circuit occurs. Here the electrical current in the circuit and at the source (for example, a battery) can be so high that these become hot and the risk of burn injuries occurs on contact or hazardous substances harmful to health can escape.
- Before use ensure that all electrical components are in a good condition. Do not use damaged components!
- Operate the components only with batteries of the type AA (Mignon LR6) with 1.5 Volt. Rechargeable batteries must not be used.
- Do not use any wet or damp electrical components!
- The battery holders of this instructional construction set are equipped with protective devices for switching off in the event of a short circuit or overload. Do not manipulate these, for example, by bridging them and replace defective fuses only with the same type supplied as specified by the manufacturer.

The electronic instructional construction set consists of 42 parts. Batteries are not included in the scope of supply.

Advice about Disposal

Batteries do not belong in the household waste. The old batteries can be disposed of in public collection points or everywhere in places where batteries are sold.

Operation and Storage

- Only use the electronic instructional construction set in a dry environment and with dry hands.
- Store the electronic instructional construction set out of the reach of small children.
- Operate the components only with batteries of the type AA (Mignon LR6) with 1.5 Volt. Rechargeable batteries must not be used.

Maintenance and Cleaning by the User

Disconnect the components to be cleaned from the power supply.
Wipe the components exclusively with a damp cloth. Do not use any cleaning agents. Allow the components to dry fully before their next use.

Fault Finding

Possible causes when a light bulb does not light up:

- Has the light bulb been screwed into the mount correctly?
- Has the power circuit been closed? Are all parts firmly connected with each other? Check the connections!
- Is the filament (spiral-wound filament) in the bulb in order? If necessary, replace it!
- Is the battery charged? If necessary replace it!
- Is the fuse in the battery holder defective? Replace this with the accompanying microfuse 2A flink 250V (F2AL250V)

Possible causes if when on connection the solar cell of the motor does not move:

- Halogen spotlights are not suitable as light sources, Use normal light bulbs as light sources.

In the event of further questions:

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Spare parts and Repairs

Spare lamps, Mignon batteries, micro-fuses 2A flink 250V (F2AL250V) can be obtained from the place of purchase.

Guarantee and replacements

In addition to the legal guarantee (and without reducing it) you receive 2 years of total guarantee. That means, you do not have to prove that articles were already damaged at purchase. In case of guarantee, contact place of purchase.

1. The Construction kit – Electric current

The construction kit "Electric Current for Primary Schools" contains the following parts:

- Connections in different lengths with 2 to 6 poles
- Press switch
- Slide switch
- Light bulbs
- Lampholders
- Battery holder
- Direct current motor with propeller
- Cable with alligator clips
- Flat battery
- Iron screw
- Non insulated wire
- Solar cell
- Different conductors and non-conductors

The components of the construction kit "Electric Current for Primary Schools" are – but for few exceptions – labelled with the internationally valid wiring symbols.

All the parts are included to conduct the experiments on the mastercopies. You only need some paper clips and some more objects to be found in every household.
With the help of this educative construction set you can cover the major part of the subjects demanded in the curriculum, and perform the claimed experiments. All the experiments are safe, as they are performed with low voltage batteries.

Point out to your students the dangers of electric current. Together, you can decide on rules when working with electric current!
(See: Electric current is dangerous! Therefore I follow these rules.)
Make sure your students do not construct an electric circuit without a consumer. Otherwise the battery will be empty in no time, which will heat the cable and can cause in a short circuit.

2. Didactical indications

Teaching is supposed to help children and teenagers to get to know their world. Nowadays our world is – more than ever – shaped by electricity. Therefore it is important to make their electric world and environment transparent and understandable.
Children and young people know a lot about electric phenomena from daily life, like lightning, or the electrostatic charge of hair, or electric fences. These must be made aware of, and backed with theory, in order to contribute to a deep understanding of physics.
The knowledge of the electric current, which the students acquire now, establishes a base for further natural scientific teaching.
Children and young people have but a very fuzzy idea about electricity. They do know that electricity is very useful, and they know, too, that it can be dangerous. On the one side, students cannot imagine current as such, since only its performed work is "visible" in form of light, heat, movement, or magnetism. On the other side, it is also important for the students to acquire knowledge about the conductivity of different materials, in order to be able to protect themselves from the dangers of electric current.
For teaching these subjects, experiments are an ideal medium to demonstrate electrical phenomena, or to illustrate ideas, but also to experience electricity, and to create references to practical life.
For example, you can check electric equipment for its security. Pictures and stories about the use of electric current can be examined as to the dangers, or as to the correct or incorrect behaviour of the people involved. It is getting more and more important to operate household equipment appropriately; not only because electricity continues to become more expensive, but also, because the energy required by humans is provided mostly by non renewable resources, such as mineral oil, natural gas, coal, and uranium; these energy sources will come to an end in the foreseeable future. Subjects like energy and electricity saving, as well as energy generation from renewable energy sources (wind, water, sun) therefore are of the utmost importance. Children and young people must learn, where electric current is used, and how to use it responsibly.
Children and young people must be made aware of what life would be like without electricity, and which processes and equipments need electricity to work. That is the only way to enable them to use electric current responsibly.
They should also be shown alternatives, like, for example the generation of electricity by solar collectors.

3. Possible Objectives of the Lesson

- To build a simple electrical circuit
- To be able to distiguish between electricity sources and electricity consumers
- To distinguish and name the components of a simple electrical circuit
- To be able to name electricity consumers in the household and at school
- Investigate the electrical conductivity of materials
- Learn about some good and some bad electrical conductors
- Build a simple switch out of everyday materials
- Recognize how a short circuit occurs
- Test the electromagnetic effect of electricicty
- Self-build a simple electromagnet
- Examine the different effects of electric current: heat, light, motion, magnetic effects
- Examine various electrical devices for the exploited effect
- Apply a simple electric circuit:
  - Use heat, light, movement or magnetic effects
  - Model traffic lights
  - Doll‘s house illumination
  - Dexterity game
- Examine a simple electric motor
- Know the dangers of electric current
- Know the dangers when handling electrical devices
- Know how to use electricity responsibly
- Identify the importance of electricity in everyday life
- Understand the need to save electricity
- Find possible ways of saving electricity – in school. too
- Awareness-raising of necessary and unnecessary use, for example, stand-by switching
- Know the opportunities and risks of electricity generation
- Distinguish between different kinds of renewable energy and recocognize the advantages

4. Technical Analysis

We meet electricity all the time in our daily lives and we can hardly imagine a life without it. But most of us know very little about it. The subject is very extensive and we would like to give you an overview here which goes beyond the subject areas dealt with in the suggested experiments.
You will learn all the important points briefly and simply explained. Thus you can impart the necessary technical knowledge to your pupils and understand the background of the experiments.

2.1 The activations of electric current

Electric current is only visible for us via its work- that is, its activations.
a) Activation of light:
Electric current can produce light in a light bulb.
b) Activation of heat:
Electric current can heat up the heating element in a stovetop, in immersion heaters, or in the heating panel of the iron, or in water boilers.
Lead fuses too, function due to the heat activation of electric current. Light bulbs too, heat up when lit.
c) Activation of magnetism:
Due to ON - OFF system electromagnets are used in scrap yards.
d) Chemical action:
Electric current is used, for example, in electroplating.
e) Mechanical work - movement:
Electric current moves for example, the mixer, or the ventilator.

In the refrigerator or the freezer, but also in air conditioning, the cold is produced by electric current.

2.2. Electric charges

All matter consists of atoms and molecules. In the atomic shell there are electrons charged negatively, whereas the atomic nucleus is charged positively. The electric charge indicates the amount of excess/or lack of electrons in an electrically charged matter. Depending on whether a matter is charged positively or negatively, it receives the according sign – plus or minus.
Same charges repel on another, while opposite charges attract one another. The identical amounts of non opposite charges are demagnetized, that means they even out. The electric charge has the formula symbol Q and is specified in the unit Coulomb by the sign C.
Evidence of electric charges is provided by an electroscope.
Electric charges can be calculated with the following formula:

$$Q = 1 \cdot t$$

I = amperage t = time

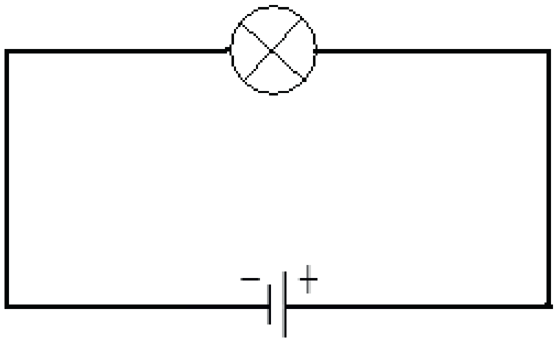
2.3. Electric circuits

Electric charges can be transferred by electric conductors, like metals. There the charges are transported by electrons. This directed movement of the charge carrier within a circuit is called electric current.

2.3.1. A simple electric circuit

A simple, closed circuit consists of a voltage source (for example a battery or a solar cell), and an electrical component/ equipment (for example a light bulb) which are connected by electric wires (for example a cable).

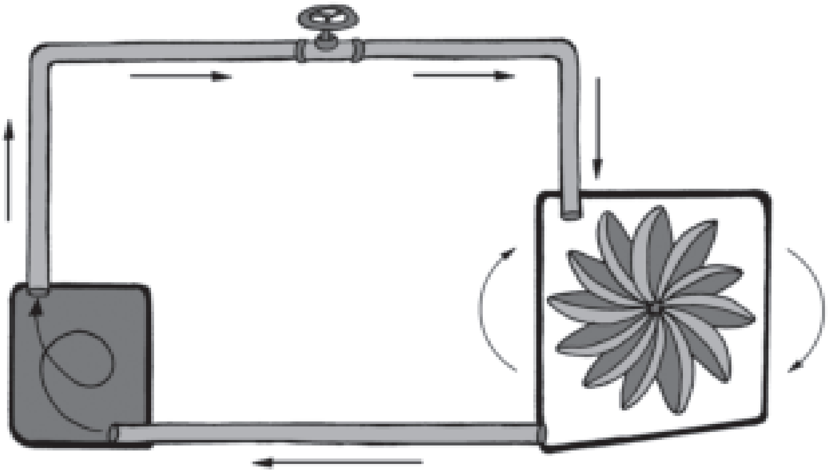
Circuit diagram with battery and light bulb:



Power sources always have a positive pole (+) and a negative pole (-).
Electric circuits are illustrated with the help of circuit diagrams and nationally/internationally standardised wiring symbols. (Example: see page 18/19).

2.3.2. An electric circuit model

Analogue models can help to understand the occurrences in an electric circuit. One model representing the electric circuit is the model of the watercycle. The water circulates in a closed tube-system, where a pump and a turbine are inserted. When the pump is switched on, it pushes the water along the pipe into the turbine, which is turning, and the water flows back to the pump. Is the valve closed, no more water flows through the tubes.
The tubes represent the cables of the electric circuit, the water pump represents the battery/current source, the turbine replaces the lamp, the waterdrops represent the electrons, and the valve stands for the electric switch.



2.3.3. Conductors and non-conductors

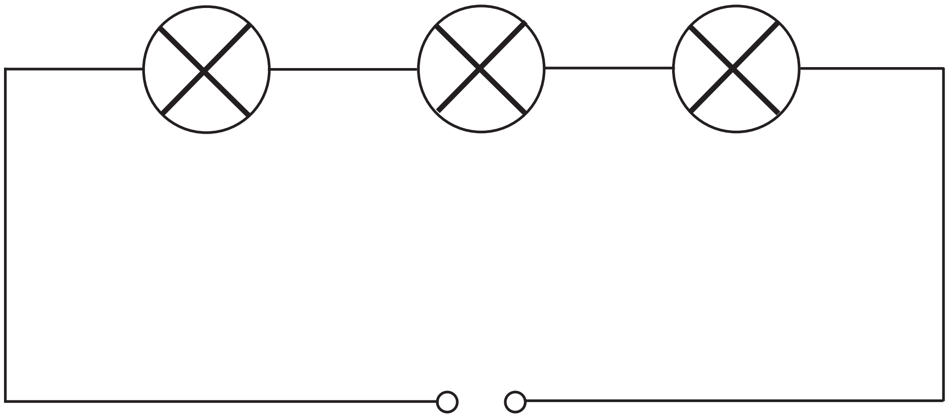
Different objects conduct electric current in different intensities. The conduction of electric current depends on:

- The material of the matter
- Its length
- Its cross-sectional area

Matters, that conduct the electric current well, are called conductors. Inside of them electrons that can transport the charge can move freely. Matters, that can barely, or not at all, conduct electric current, are called non-conductors or insulators. Most metals are conductors, but also coal and black lead (graphite). Saline solutions, acids, and alkaline solutions conduct too, but not very well. Among the insulators or non-conductors are: plastic, cloth, ceramic, glass, air, and dry wood. Insulators make it possible for us, to touch electric cables without danger.
Furthermore, there are semi conductors, which only conduct electric current, when influenced by heat or light. When there is neither heat nor light affecting them, they behave like insulators.

2.3.4. Series connection

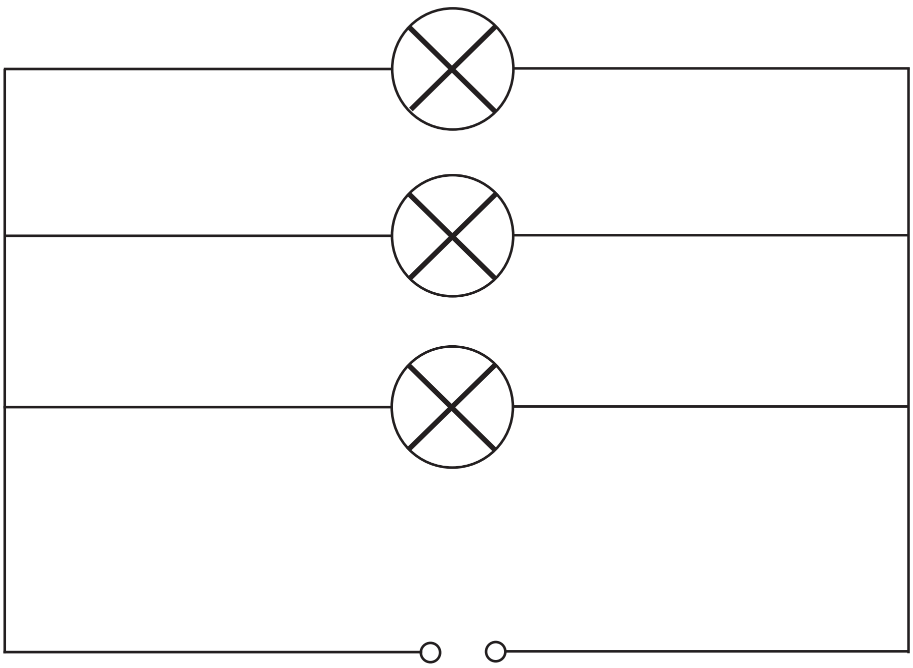
In a series connection, also called cascade connection, all the current sources and other parts are arranged in series.
Example: Series connection with light bulbs:
For example: light bands on Christmas trees. If one light is damaged, all the others go out, too.



In a series connection all power consuming devices receive the same amount of power. The voltage in these connections is divided by all the power consuming devices, which means, it diminishes towards the last one. In the above connection you can see, that every lamp only receives 1/3 of the tension. Batteries, too, can be arranged in series connections.

2.3.5. Parallel connection

In a parallel connection, also called shunt connection, all power sources and other parts are connected parallel. Example: Fuses in the apartment. All devices can be run at the same voltage and switched on and off individually.



In a parallel connection the same voltage is in all power consuming devices. Therefore all the lamps (of the same type) shine equally bright in this connection.

2.4. Direct current circuit

When a battery is connected to a small light bulb, the current always goes into one direction, and the voltage does not change, that means it flows quite constantly.

2.4.1. Electric amperage

The electric amperage indicates how much electric charge per second, runs through the cross section of an electric conductor. The symbol for the electric amperage is I. Amperage is measured in ampere. (Electric amperage is measured with an ampere-meter. The ampere-meter is switched in series with the electric device, so that the same electric current flows through. Amperage is calculated with the following formula:

$$I = \frac{Q}{t}$$

Q= electric charge   t= time

2.4.2. Electric tension (voltage)

The electric tension indicates the intensity of the drive of the electric current. The symbol for electric tension is U. Tension is measured in volt (V). Electric tension is measured with a voltmeter. Voltage control is switched parallel to the electric device. Electric tension is calculated with the following formula:

$$U = \frac{E_{el}}{Q}$$

Eel = the electric energy/ work
Q = the electric charge

2.4.3. Electric resistance

The electric resistance describes the ability of components to inhibit the current flow. There the movement of electric charges is inhibited. The more tension is needed to send current through a component, the stronger is its electric resistance. Or, the more the current flow is obstructed, the stronger is the resistance.
The electric resistance indicates the tension needed for an electric current with the intensity of 1 ampere. The symbol for the electric resistance is R. The electric resistance is measured in Ohm (Ω).

$$1\,\Omega = \frac{1V}{1A}$$

The electric resistance is measured with an ohmmeter.
It can be calculated with the following formula:
U = electric tension   I = electric power

$$R = \frac{U}{I}$$

The specific electric resistance however, in contrast to the general electric resistance, indicates the resistance of an electric conductor with the length of 1m and a cross-sectional area of 1mm.
Technical equipment often needs electrical components that have a constant, or an adjustable resistance. The value of constant resistances is internationally determined by colourcodes.

2.4.4. Electric energy and work

Electric energy is the ability of the electric current to perform mechanical work, to generate heat or to emit light. The symbol for electric energy is E_{el}.
Electric energy is measured in joule (J) or in watt-seconds (Ws).
The electric energy can be measured with a electricity meter.
The electric energy in an electric circuit is the stronger:

- the stronger the electric voltage is
- the stronger the electric power is
- the longer the circuit is working

Electric energy cannot be stored in bigger quantities.
Electric energy can be calculated with the following formula:
U = electric tension   I = power   t = time

$$E_{el} = U \cdot I \cdot t$$

2.4.5. Electric output

Electric output indicates the amount of electrical work the electric current performs every second. The symbol for the electric output is P. The output is measured in watt (W). Electric output is measured with a wattmeter.

It can be calculated with the following formula:
P = W/t   W = electric energy   t = time

$$P = \frac{E_{el}}{t}$$

2.4.6. Summary

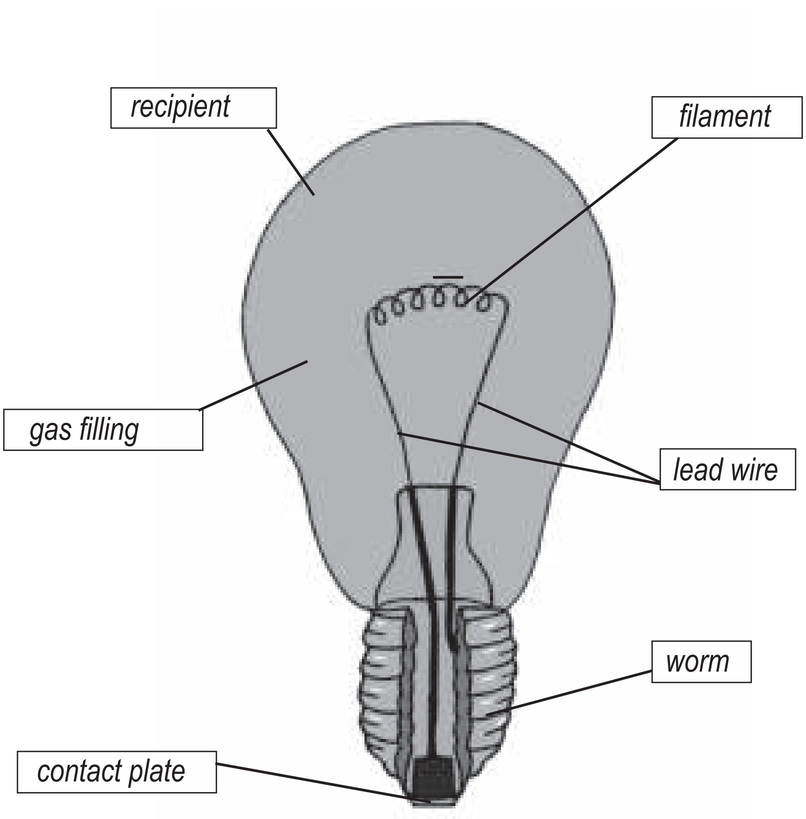
Parameter		Scale unit		Formula	Definition
Electric charge	Q	Coulomb	C	$Q = I \cdot t$	Indicates the amount of excess/ lack of electrons of an electrically charged material.
Amperage	I	Ampere	A	$I = \frac{Q}{t}$	Indicates how much electric charge per second runs through the cross section of an electric conductor.
Electric tension	U	Volt	V	$U = \frac{E_{el}}{Q}$ $U = \frac{\text{Energie}}{\text{Charge}}$	Charge-specific work capacity of a charge, indicates the drive-intensity of an electric current.
Electric resistance	R	Ohm	Ω	$R = \frac{U}{I}$	Capacity of components to inhibit the current flow. The more tension is needed to drive a current through a component, the stronger is its resistance.
Electric capacity	P	Watt	W	Gleichstromkreis $P = \frac{E_{el}}{t}$	Capacity is electrical work performed during a time unit.

Electric energy/work	E_{el} W	Joule	J Ws	$W = E_{el}$ $W = U \cdot I \cdot t$	Represents the ability of electric current to perform mechanical work, to emit heat or light.
Time	t	Second	s		

2.5. Simple electric motor

An electric motor is a machine, which converts electric energy into mechanic energy. This is done electrically with the help of magnetic fields. In electric motors, the power that is transferred from a magnetic field onto the conductor of an inductor is converted into movement.

2.6. Light bulb

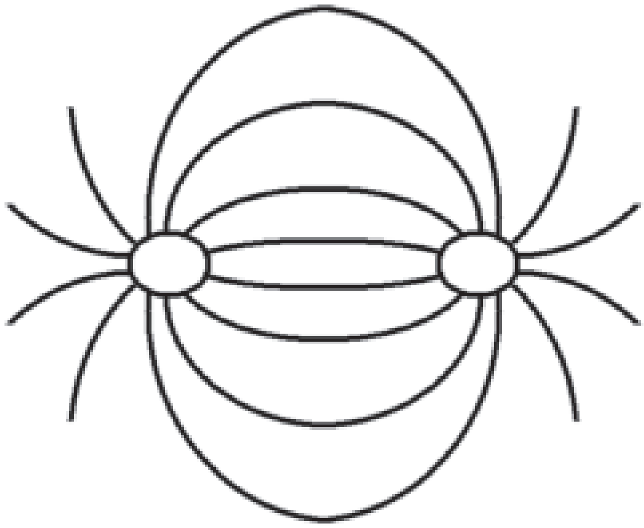


Within a light bulb, an electric conductor – a filament – which mostly consists of the metal Wolfram, is heated by current flow to such an extent that it glows. This metal only melts at 3400°Celsius, and within an activated light bulb the temperature is between 2500° and 3000°Celsius.
Practically the total energy supplied, is converted into visible light energy – the loss due to heat conduction is negligible.
The filament is spiralled. Spiralled twice, more wire fits into the bulb, thus producing more light.
In order not to make the filament boil or evaporate, the recipient is filled with nitrogen or an inert gas at low pressure. A light bulb has a power of 25 up to 100 watts, and it only glows when one of the battery poles is connected to the worm, and the other pole is connected to the contact plate, thus closing the circuit.

2.7. Electric field

An electric field is the condition of the area around an electrically charged matter. Within this area, the electrically charged matter has an impact on other electrically charged matters. This is to be seen at the attracting and repelling forces, which act between two electrically charged matters. The electric field power is specified by the symbol E, and has the unit newton per coulomb, or volt per meter. Electric fields can be shown in electric field patterns.

Example: Electric field pattern of two balls with opposite charges:



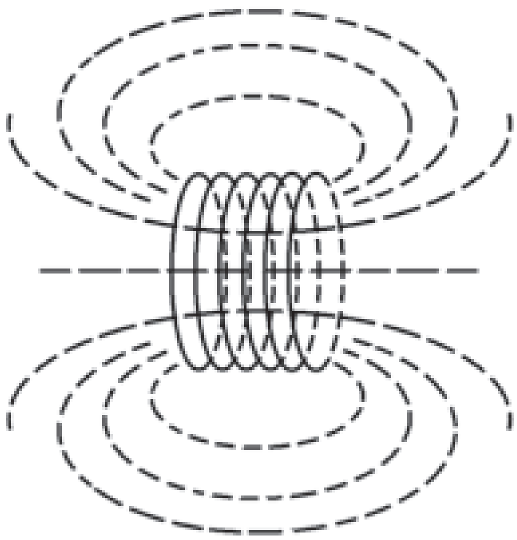
2.8. Magnetic field of a solenoid (electromagnet)

All electric conductors are, when activated, surrounded by a magnetic field. The magnetic field is specially strengthened when a conductor has been coiled onto an inductor including a core.
The magnetic field power H depends on:

- amperage
- number of turns
- length of the inductor.

The magnetic field power has the unit ampere per meter.

Example for the magnetic field of a conductor, that has been coiled around a spool.



2.9. Alternating current

When a little light bulb is connected to a battery, the electric current always flows into one direction and the electric tension does not alter.
In the alternating current however, the direction of the current changes periodically. The frequency of the current indicates how often the current changes direction in a second.
In Europe the usual current has a tension of 230V, and a frequency of 50Hz (hertz).

2.9.1. Alternating current generator

The alternating current generator generates voltage by using the law of induction. Induction means the generation of electric tension by a variable magnetic field.

2.9.2. Transformer

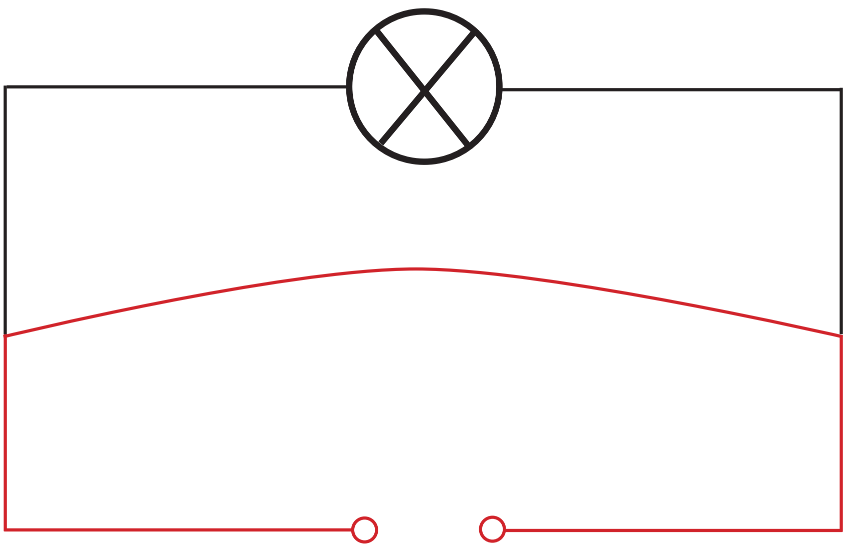
With a transformer electric voltage can be increased or decreased. So the voltage can be fitted to the technical demands of electric devices. The line voltage can be decreased down to values no longer dangerous, for example in toys.
The transformer also makes it possible to transport electric current over great distances by high voltage power lines.

2.10. Dangers in current

At about 42V voltage becomes perilous for humans. (For animals already at 24V).
Direct current is already dangerous to life at 120V (animals at 60V).
Most household equipments work at 230V. This voltage is also provided by electric outlets.
Electrical experiments with batteries are considered hazard-free up to about 9V. Experiments are NEVER to be performed with current coming from an electric outlet.

2.10.1. Short circuit

If electric current is given the possibility of flowing from one pole to the other, without passing through a device, it will take this opportunity. This is called a short circuit.
There, the electric current in the conductor and in the source can amount to such an extent, that they heat up and fires can occur. Short circuits are usually caused by damaged isolators, dampness, or switching errors in electric arrangements. The picture shows the current flowing through a short circuit without passing through a device.



2.10.2. Fuses

The electric fuse interrupts an electric circuit in case of the electric current rising too high, due to a short circuit or an over-charge. So, cables and machines connected, are protected from damages caused by overheating.

2.10.3. The effects of electric current on humans

Practically all human and animal organs function due to electric pulses, sent by the brain. These electric pulses are transmitted by the brain via the nerves, to the intended organs, for example the muscles. The tension of these electric pulses is at about 50mV. These electric pulses in our bodies can be measured. The electrocardiogram shows the heart's electric activity; the electroencephalogram however, shows the brain's electric activity.
Electric currents coming from outside, can influence the functioning of the organs.
This fact used medically, for example in cardiac pacemakers. But – when an electric current from outside superimposes the body current, because it is much stronger, this might do harm to the organs concerned, possibly resulting in cardiac fibrillation or in muscular cramps.
The current flowing through the body depends on the tension and the resistance of the body. Dry skin and clothing have a stronger resistance than damp/wet skin or clothing.
The heat effect of the current causes burns at the inlet and the immersion points.
Even the carbonisation of body-parts might occur.

2.10.4. Rules for the handling of electric current

- Before every use ensure that the equipment is in perfect condition.
- Do not use wet equipment
- Disconnect or unplug the jack immediately at any kind of disfunctioning
- Never tinker with electric equipment while it is switched on.
- Secure the sockets to protect children in the household
- Have defect electric installations repaired immediately, and disconnect them from the current until then (if possible).
- Do not use damaged cables or equipment
- Before drilling or nailing into walls, check if there are cables running through the wall. (Checking device)
- Refrain from experiments with current stronger than 25Volt
- Never touch the poles of a socket, or bare or damaged cables.
- Always pull the jack and never the cable.
- In dangerous circuits always add fuses, or a circuit breaker.
- When a fuse is damaged, rearrange the cause of the damage, before inserting a new fuse.
- Always connect electric equipment always to the correct electric source, as the tension of the source and the equipment must correspond.

2.10.5. First aid guide

- Interrupt the current flow by switching the equipment off, by pulling the jack, by unscrewing the fuse… If that is not possible: separate the injured person from the power supply with the help of insulating elements.
- Check the breathing
- Check the pulse
- Eventually start cardiac massage and rescue breathing.
- Put through the emergency call
- If the injured person is breathing independently, to put him into recovery position
- Continue first aid.

2.11. Electricity generation

Electricity generation means the large scale supply of electric energy in form of electric current in a power station. Electric energy can be gained from different energy sources. These are divided into renewable and non-renewable ones. Nowadays, energy is gained mostly from non-renewable sources, but the actual trend goes towards regenerative, that is renewable energy sources.

2.11.1. Non-renewable energy sources

The expression "non-renewable" is actually wrong, because these energy sources too, renew themselves within a very long time of several million years. We – the humans, do not witness these "regenerations" and therefore we call them finite e.g. limited.
Not renewable are fossil or atomic energy sources, like mineral oil, natural gas, stone coal, brown coal, uranium, and thorium.
Fossil energy sources (mineral oil, natural gas, stone coal, brown coal, turf) have developed by biological and physical events in the interior and on the surface of the earth, during long eras.
The expression "fossil fuel" is generally used only for those fossil energy carriers, which emit their stored energy by chemical burn-ups with oxygen. During these burn-ups not only energy is emitted, but also other burn residues like CO^2, which reinforce the greenhouse effect and so influence our climate. The statistic coverage of these energy sources is about 90 years, for mineral oil even less.

2.11.2. Renewable energy sources

Renewable energy is also called regenerative energy. These are energy sources which, at present, seem, and might well be, exhaustless, because they always renew themselves. The humans only take the quantity that can renew itself. On earth, the following energy sources can be used: wind energy, hydraulic energy, tidal streams, sunlight, and solar heat. All renewable energies depend on 4 basic sources:

- The planetary motion, caused by gravitation → tidal power plant
- The internal heat → geothermal power or heat plant
- The radiation energy from the sun, caused by the nuclear fusion in the sun's interior, -solar cell and biomass.
- The global warming → ocean temperature gradient, power station, heat pump, hydroelectric power plant, wind power station, and wave power plant.

2.12. Some energy saving tips

- Energy saving lamps need about 80% less current than regular light bulbs, and they last eight to ten times longer.
- Do not switch on the light unnecessarily.
- Do not place the stove next to the fridge, because the heat emission of the stove increaser the fridge's need for energy.
- Cooking needs less energy when the lids of the pots fit tightly and the pots' sizes are the same as the hot plates'.
- Nowadays there are energy saving models of refrigerators, washingmachines and dryers.
- Open the doors of cooling devices only for a short time.
- Let food cool down before storing it in the fridge.
- Only run washing machines and dishwashers when they are full.
- Rather shower than take a bath, that saves water and energy!
- Preferably ventilate several times shortly, rather than always leaving the window slightly open. Switch off the heating devices when ventilating a room.
- Switch off unused appliances instead of using the standby mode.

3. Current consumption of different devices

One year's current consumption of different electric devices in kilowatt-hours.

Consumption in kilowatt-hours per year ►	**2 personhousehold**	**4 personhousehold**
Washingmachine	170	320
Clothes dryer	245	470
Refrigerator	350	410
Freezer	380	440
Dishwasher	220	390
Electric stove	415	600
Hot water - bathroom	780	1390
Hot water - kitchen	300	440
Lights	340	470
Other small devices	450	690
Support devices for central heating	290	370
TV, radio, video	155	200
Satellite receiving equipment		240
PC and printer		210

What can one kWh poer?

- Ironing 15 shirts
- Preparing 70 cups of coffee
- Watching TV for seven hours
- Two days use of a 300 l fridge
- Baking a yeast cake
- Cooking lunch for four
- A full washing machine cycle
- 90 hours of light with an energy-saving-lamp of 11 watts
- 17 hours of light with a light bulb of 60 watts
- Two days on your laptop

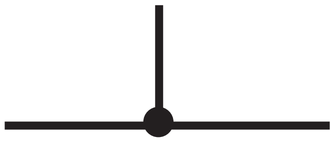
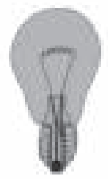
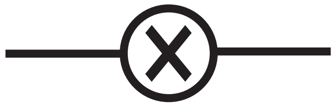
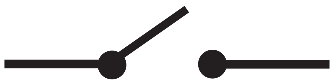
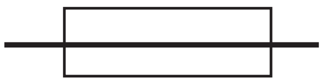
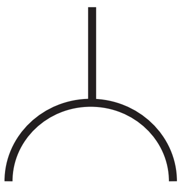
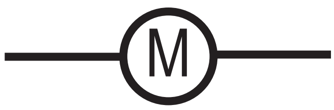
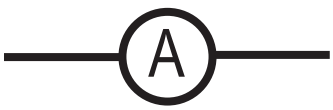
4. History of electricity and current

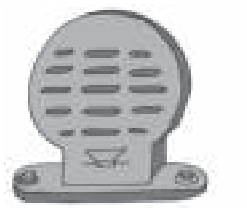
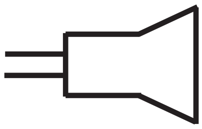
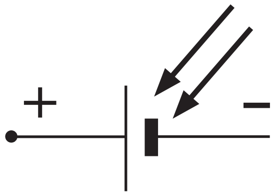
Year	Country	Name	Profession	Discovery, Invention, Development
600 BC	Greece	Thales of Miletus	Philosopher/ Mathematician	Electrostatic adhesion: When amber is rubbed against the fur of an animal, small particles like feathers or straws stick to the stone.
600 BC	England	William Gilbert	Physician/ Physicist	Friction experiments, introduction of the expression "electric" from elektron = Greek for amber.
1672	Germany	Otto von Guericke	Physicist	Friction machine, that can produce electric charges (first electric generator).
1733	France	Charles François de Cisterney du Fay	Scientist	Proof that there are two different types of electric charges (positive and negative).
1745	Netherlands Germany	Pieter van Musschenbroek Ewald Georg von Kleist	Physicists	Leyden jar Kleist jar Independent development of a capacitor
about 1750	Germany	Johann Heinrich Winkler	Physicist	Improvement of the electrifying machine, production of electric light (first illuminated signage).
1752	America	Benjamin Franklin	Explorer, Politician, Author	Recognises that lightning is an electric phenomenon. Invents the first lightning rod.
1780	Italy	Luigi Galvani	Physician	Observes "animal" electricity on frogs' legs.
about 1780	Germany	Georg Christoph Lichtenberg	Mathematician/ Physicist	Constructs the electrophorus which produces sparks of more than 40cm length. Introduces the mathematical symbols "plus" and "minus" for the two types of electricity.
1785	France	Charles Augustin de Coulomb	Physicist	Establishes Coulomb's Law.
1799	Italy	Allessandro Volta	Physicist	Develops the forerunner of today's battery (Volta column), and invents the electrophor (gadget to separate charges).
1810-1812	England	Humphry Davy	Chemist	Generates a light arc between two carbon pencils, and thus creates the base for the arc lamp.
1820	Denmark	Hans Christian Oersted	Physicist	Discovers that electric currents generate magnetic fields. Development of the first galvanometer.

1820	France	André-Marie Ampère	Physicist	Develops a theory for electromagne-tism. Invents the Amperemeter and develops the theory for the electric telegraph and the electromagnet
1821	Britain	Michael Faraday	Physicist/Chemist	Forms the foundation of modern electric motor technology.
1826	Germany	Georg Simon Ohm	Mathematician/ Physicist	Develops Ohm's Law = the connection between amperage, tension, and electric resistance.
1831	Britain	Michael Faraday	Physicist Chemist	Invents the operating principle of the modern generator.
1833	Germany	Carl Friedrich Gauss and Wilhelm Eduard Weber		First practical use of a telegraph.
1866	Germany	Werner von Siemens	Engineer/Industrialist	Invents the self-excited generator, a practically usable dynamo.
1877	America	Thomas Alva Edison	Telegraphist/Inventor	Makes the light bulb applicable.
1882	America	Thomas Alva Edison	Telegraphist/Inventor	Construction of a power station, develo-ped by him, for the production of electric current. Works with direct current.
1884	Germany	Heinrich Hertz	Physicist	Proves the existence of electromagnetic waves.
1891	America	Nikola Tesla and Georg Westing-house	Electrical engineer/ Industrialist	Continue the development of alterna-ting current. Development of the transformer.
1897	Germany	Ferdinand Braun	Physicist	Invents the Braun Tube (cathode ray tube).
1930 – 1938	Germany	Otto Hahn and Fritz Strassmann	Physicists	Large surface household electrification. Discovery of the principle of nuclear fission.
1948	America	John Bardeen and Walter Houser Brattain	Physicist	The discovery of the transistor effect causes a new technology thrust, and a miniaturisation of electric equipment.
1951				Foundation European Network of Transmission System operators for Eleytricity (ENTSO-E).
1954	America	Bell Laboratories		By chance the principle of solar cells is discovered.
1955	England			Lauch of the first commercially operated nuclear power station.
1960	America	Theodore Harold Maiman	Physicist	Construction of a ruby laser, and the generation of the first laser light.

1967	France			The first tidal power station world-wide (240MW) is opened.
1981	Italy/Sicily			The first big solar power station EURELIOS is launched.
1982	California			A photovoltaic powerstation or solar park plant of 1-MW- is put into operation.
1982	Switzerland/ Lugano			The biggest European photovoltaic power station (15 kW) is put into operation.
1983	Germany/ Brunsbüttel			The first big wind turbine is put into operation.
1986	Ukraine/ Tschernobyl			Serious accident in the nuclear plant in Tschernobyl.
2002	European Union			The European ministers of energy - reached an agreement on the opening of the energy markets. From July 1st 2004 and from July 1st 2007 respectively, industrial and than domestic customers are free to choose their gas and electricity suppliers.

5. Important electrical symbols for circuit diagrams

Device	Symbols	Name
		Conduction or cable
		Distribution of cables, the connection is stable.
		Battery, accumulator, current source for direct circuit.
		General voltage source
		Light source
		Open contactor (switch)
		Closed contactor (switch)
		Fuse
		Socket
		Motor
		Amperemeter

		Loudspeaker
		Solar cell

6. Possible subjects for teaching

Electricity and our daily life	Daily electrical equipment, life without electricity → electricity blackout, significance of electricity
Electric circuit	Simple electric circuit Closed circuit Open circuit Comparison: water circuit - electric circuit
	<u>Light bulb:</u> Construction Flow of charge What makes a light bulb emit light?
	Series connection Parallel connection
	Current sources Conductor Power-consuming appliances
	Conductor and non-conductor (insulator) Conductivity Salt water as conductor
	Contactor (switch)
	Wiring symbols Circuit diagrams
	<u>Use and profit of an electric circuit:</u> Dexterity game Magnet Light Sound Movement
	Solar cells
	Simple electric motor
Current effects	Heat (Cold → fridge) Movement Light Magnetic effect (Sound → radio, TV) Chemical effect

Dangers and protective measures	When does it become dangerous? Tensions above 42 Volt is dangerous! Check equipment for danger signs Protective measures / safety rules Short circuits Fuses
Saving energy	Check the current consumption of devices Dispensable and non-dispensable equipment To find energysaving possibilities Energy-saving lamps
Energy generation	Where does electricity come from? Generation of current: wind, water, natural gas, mineral oil, coal … Renewable and nonrenewable energy sources Limited resources

7. Possible objectives of teaching units

- To build a simple circuit.
- To be able to differentiate current source and current consumer.
- To differentiate and to name the components of a simple circuit.
- To be able to name power-consuming appliances at home and at school.
- To examine the conductibility of materials.
- To know some good/bad conductors.
- To build a simple conductor/switch from everyday material.
- To recognise how a short circuit happens.
- To try out the electromagnetic effects of current.
- To build a simple electromagnet.
- To examine the different effects of current: heat, light, movement, magnetic effect.
- To examine different appliances as to their use of: heat, light, movement, magnetiv effect.
- To apply a simple circuit:
    - To use heat, light, movement or magnetic effects
    - Model of traffic lights
    - Illumination of a doll’s house
    - Dexterity game
- To examine a simple electric motor.
- To know the dangers of electric current.
- To know the dangers when working with electric equipment.
- To know how to use current in a responsible way.
- To understand the significance of electric current in daily life.
- To understand the need of energysaving.
- To find possibilities of energysaving – even at school.
- To be sensible as to necessary and unnecessary consumption (i.e. standby mode).
- To know the possibilities and the risks of energy generation.
- To differentiate renewable types of energy, and to know their advantages.

8. Experiments in class

8.1 Characteristics of classroom experiments

- Repeatability:
  The experiment must be repeatable, and every attempt must have the same result. This can be observed in class, where the students compare their results, and see, that they are very similar.
- Conservation:
  Elements, which are parts of an experiment do not get lost. They are conserved in another type of form. For example the electric energy is transferred into work, that is movement, heat, or light.
- Organisation:
  Children try to integrate experiences and observations into their environment and their previous findings. They try to use their previous knowledge to explain and categorize their observations. This is supported by experiments, because they are repeatable, and can be performed by the children themselves

8.2. Purpose of classroom experiments

Didactic and methodical functions of experiments:

- Illustration and explanation
- Learning the way of looking at a problem
- Naming the problem
- Repetition of historical experiments
- To awaken interest and motivation
- Demonstration of phenomena
- Supporting the acquisitors of the appropriate terminology, and definitions of quantities
- Building up of subject-specific skills, exercise methods of experimentation
- Establishing practical references to daily life

Educational functions of experiments:

- Training of observational abilities
- Practising social behaviour
- Promoting team- and cooperation abilities
- Promoting reflective abilities
- Improving language skills

8.3. Phases of experiments

The ideal experiment goes through three phases:

a) Planning phase
During this phase the aims and the purposes of the experiment are formulated. Eventual speculations and hypotheses as to the outcome of the experiment are made – too. Furthermore it is planned exactly how to proceed and which materials and items are necessary to perform the experiment.

b) Performing phase
During this phase the experiment is put up, performed, and recorded from the beginning to the end, including the experimental set-up, the observations, and the measured values. With the aid of these recordings, mistakes, which occurred during the performance, can be detected. It is important to describe the observations in detail, but without interpreting them. The students might already form simple "if – then" relations. Example: If both cables are connected to the battery, the lamp will emit light. An interpretation would be: The lamp emits light, because the circuit is closed. This cannot be observed.

c) Evaluation phase
Observations are now analysed, and compared to the hypothesi set up in phase one, to see wether it has been verified. Results are then specified either by the students, or with the teacher help. In this phase technical terminology should be used during discussions, and also mistakes should be reviewed.

8.4. Classification of experiments

Experiments at school are differentiated by the following criteria:

a) The type of operation
- *Teacher's experiment or demonstration: the teacher demonstrates an experiment.*
- *Student's experiment: The students perform the experiment by themselves.*

b) The way of data acquisition
Qualitative: Connections between variables are pointed out, recognised, and their relations are formulated.
Example: The thinner the panel, the easier it breaks.
Quantitative: Measured quantities are collected numerically – that is in numbers.
Example: At a weight of 23kg the panel of 5mm breaks.

c) Teaching phase
- *Introducing the experiment*: To motivate students or to formulate the problem.
- *Realisation and confirmation of the experiment:* to work out and to realise connections, or to test hypotheses.
- *Repetition*: To deepen or to vary the parameter
- *Homework experiment:* To prepare or to repeat lessons.
- *Furthering experiments:* To deepen the findings.
- *Application experiment*: To experience practical use in daily life.

Example: Experiments on the effects of fertilizer.

d) Different types of performance:
- *Independent experiments*: Experiments with no need for material.
- *Experiments with devices and meters:* Measured results often cannot be realised by the sensory organs, and therefore have to be measured by special devices.
  Example: Amperage consumption.
- *Model experiments*: Models can help to understand procedures and devices, as some procedures are not directly observable. Example: Model of the water cycle to explain the electric circuit.
- *Simulation experiments:* All the important parts of a system are rebuilt in a model, which is then used to experiment, in order to gain insights into the existing system. Simulation experiments are often done with the help of the computer.
- *Thought experiments*: Experiments are conducted in one's mind, mostly beginning with the question: What would happen if…..

9. The Construction kit – Electric current

The construction kit “Electric Current for Primary Schools” contains the following parts:

- Connections in different lengths with 2 to 6 poles
- Press switch
- Slide switch
- Light bulbs
- Lampholders
- Battery holder
- Direct current motor with propeller
- Cable with alligator clips
- Flat battery
- Iron screw
- Non insulated wire
- Solar cell
- Different conductors and non-conductors

The components of the construction kit “Electric Current for Primary Schools” are – but for few exceptions – labelled with the internationally valid wiring symbols.

All the parts are included to conduct the experiments on the mastercopies. You only need some paper clips and some more objects to be found in every household.
With the help of this educative construction set you can cover the major part of the subjects demanded in the curriculum, and perform the claimed experiments. All the experiments are safe, as they are performed with low voltage batteries.

Point out to your students the dangers of electric current. Together, you can decide on rules when working with electric current! (See: Electric current is dangerous! Therefore I follow these rules.)
Make sure your students do not construct an electric circuit without a consumer. Otherwise the battery will be empty in no time, which will heat the cable and can cause in a short circuit.

10. Master Copies

Nr.	Experiments and Information	Necessary Materials
1	Electric Current is dangerous!	
2	Electric Current is dangerous, therefore I follow these rules!	
3	How to make a buld light up?	Construction kit
4	Help, my lamp does not light up!	
5	Names of components?	
6	How does current flow through the light bulb?	Construction kit
7	Where does the current flow through the light bulb?	
8	How to install a switch?	Construction kit
9	What does the switch do?	
10	Why does your light bulb light up?	
11	How to insert a switch so that only one lamp lights up?	Construction kit
12	How to make several lamps emit light simultaneously?	Construction kit
13	Series Connection	
14	Help! One of the lamps is broken?	Construction kit
15	Why does none of the lights bulbs emit light?	
16	That is why none of the lamps emit light!	
17	How can 2 lamps be installed, so that both emit light of equal brightness?	Construction kit
18	Parallel Connection	
19	Which way does the current flow?	Construction kit
20	Broken light bulb - it doesn't matther!	
21	A break in the electric circuit	Construction kit
22	A break in the electric circuit (1)	Construction kit
23	A break in the electric circuit (2)	Construction kit
24	A break in the electric circuit (3)	
25	A break in the electric circuit: Conductors and non-conductors	
26	Conductors and non-conductors	
27	Current is active - current causes an effect	
28	Current causes an effect (1)	Construction kit
29	Current produces light (1)	
30	Current causes an effect (2)	Construction kit
31	Current produces movement (2)	
32	Current causes an effect (3)	Construction kit
33	Current produces heat (3)	
34	Importance of current	
35	Current produces magnetism (4)	Construction kit
36	Current causes an effect (4)	
37	What does the solar cell do? (1)	Construction kit
38	What does the solar cell do? (2)	Construction kit
39	What does the solar cell do? (3)	
40	Do solar cells only work with sunlight? (1)	Construction kit
41	Do solar cells only work with sunligh? (2)	
42	When does a solar cell produce a lot of/ little current? (1)	Construction kit
43	When does a solar cell produce a lot of/ little current? (2)	
44	The solar cell	
45	The Fruit Battery	Construction kit, fruits, nails

Electric current is dangerous! **Nr. 1**

Electric current flowing through your body is very dangerous!
The following things can happen:

- Skin burns
- Burns in the body
- Your muscles cramp, and you cannot let go of what you hold in your hand
- Your heart stops pumping
- You can die

Think of situations where electric current can be dangerous. Write them down or draw a picture.

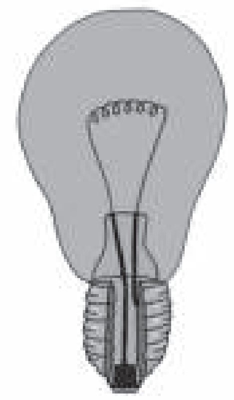
Electric current is dangerous, therefore I follow these rules: **Nr. 2**

1. I do not touch electric cables or electric devices.
2. I do not touch electric devices with wet or humid hands.
3. I do not do any experiments using current from a socket.
4. I do not touch electric devices that have fallen into the water being still connected to the socket.
5. I do not manipulate electric devices, connected to a socket.
6. I do not put my fingers into sockets.

How to make a light bulb light up?

Nr. 3

Make a light bulb emit light.
Use a cable or other components from the case.
Try out different possibilities.



Use this drawing to show what you have done to make the lamp work:

Help! My lamp does not light up!

Nr. 4

Check:

a) Is the bulb screwed in properly?

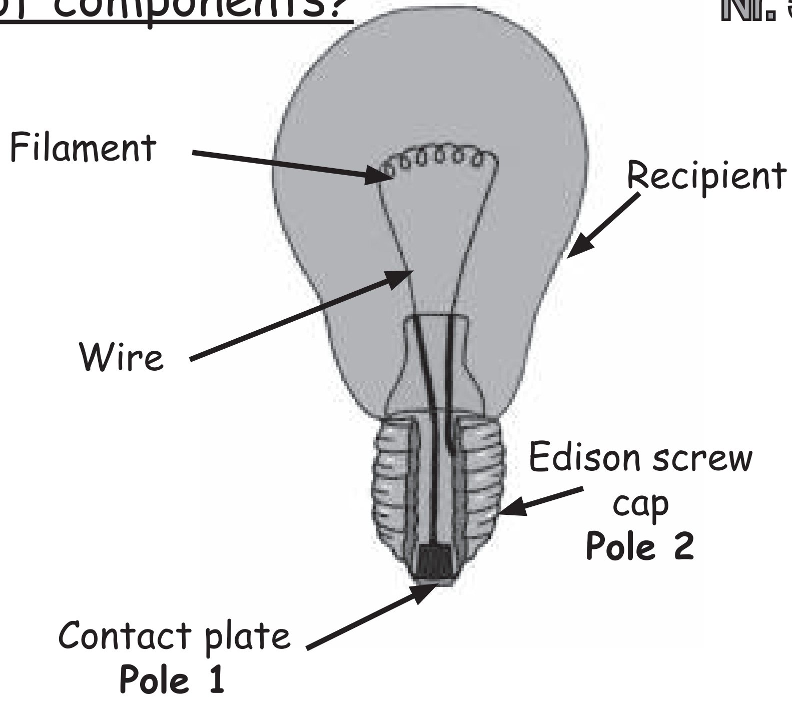
b) Is the filament within the bulb intact?

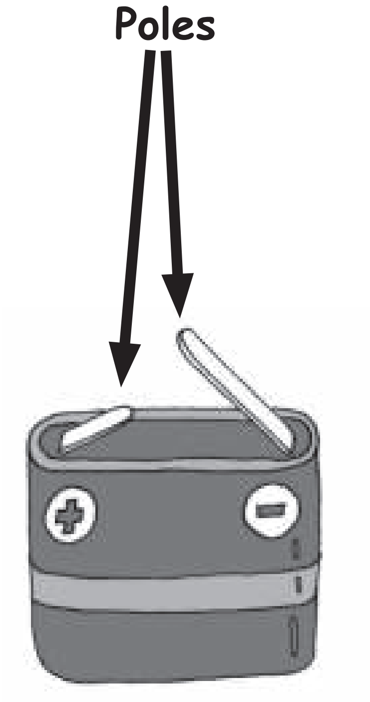
c) Are all the parts properly connected? Check!

d) Is there a break somewhere in the circuit?

e) Is the battery still charged? Try another one!

Names of components? **Nr. 5**



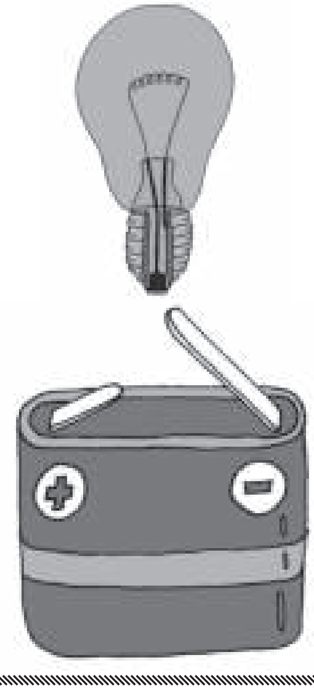


The **light bulb** emits light, when:

- one pole of the battery touches the cap AND
- the other pole touches the contact plate

How does current flow through the light bulb? **Nr. 6**

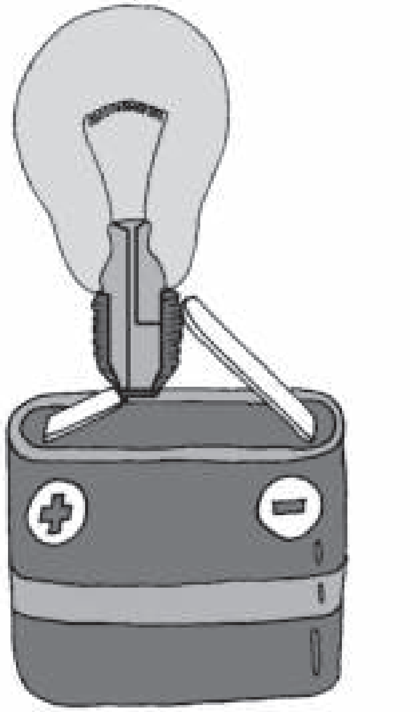
Where must the light bulb touch the battery so that it lights up?
Draw two different possibilities:



Where does the current flow through the light bulb?

Nr. 7

Current flows when the electric circuit is closed.



Describe the way of the current:

____

____

____

____

____

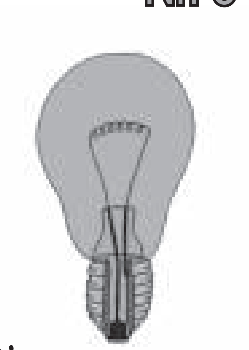
These words will help you:

battery fitting wire

interrupt to flow break

How to install a switch?

Nr. 8



Construct a circuit so that the lamp lights up.

Now add a switch to the circuit.

Draw a circuit diagram and mark the position of the switch:

What does the switch do?

Nr. 9

Write down:

What is the position of the switch when the lamp is lit? The lamp emits light when ...

Draw the switch

____

____

The expression is: "The circuit is closed"

What is the position of the switch when the lamp has not been lit? The light bulb does not emit light when ...

Draw the switch

____

____

The expression is: "The circuit is open"

Why does your light bulb light up?

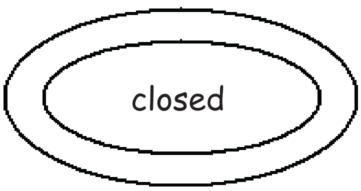
Nr. 10

Your light bulb emits light,

- because you have built a circuit through which current flows
- because the circuit has no breaks. All the components are connected. Current cannot be seen. Imagine the flow of current similar to that of water.

Water

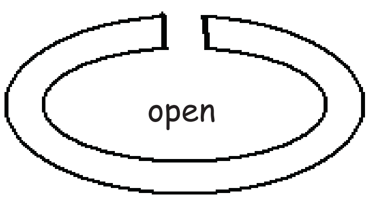
A pump makes the water move. It flows in a circle.



Current

A battery makes the electric current move. It flows in a circle.

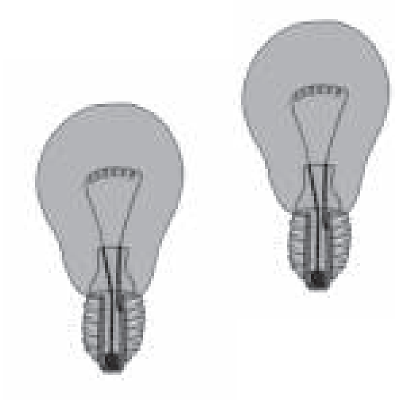
If there is a break in the water cycle, the water stops flowing.



Is there a break in the the circuit, the current stops flowing.

How to insert a switch so that only one lamp lights up?

Nr. 11

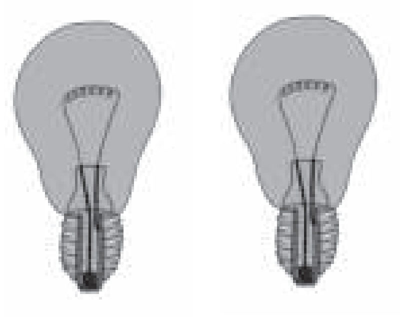


Build a circuit with 2 light bulbs.
Now install a switch so that only one of the lamps emits light.

Draw a circuit diagram and mark the position of the switch:

How to make several lamps emit light simultaneously?

Nr. 12



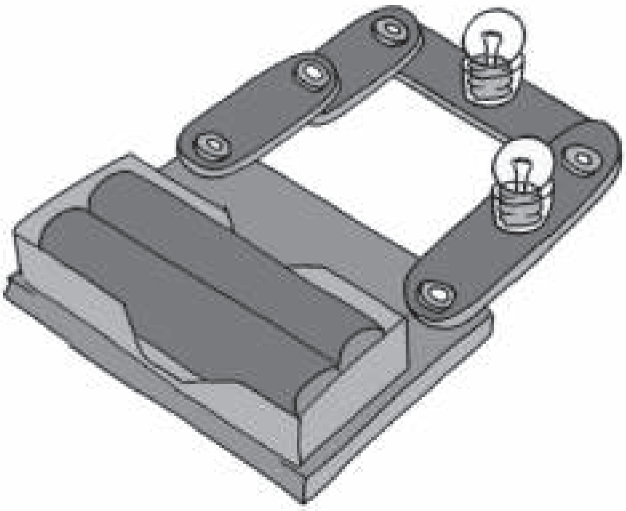
Build a circuit with 2 light bulbs with the help of the construction case.
Both lamps must light up!

Make a drawing of your circuit:

Series Connection

Nr. 13

Have you connected both your light bulbs as seen in the illustration below?



All the lamps here are in series. That is why it is called a series connection.

The current flows through the bulbs one after the other.

Help! One of the lamps is broken?

Nr. 14

Remove one of the lamps from its fitting. What do you observe?

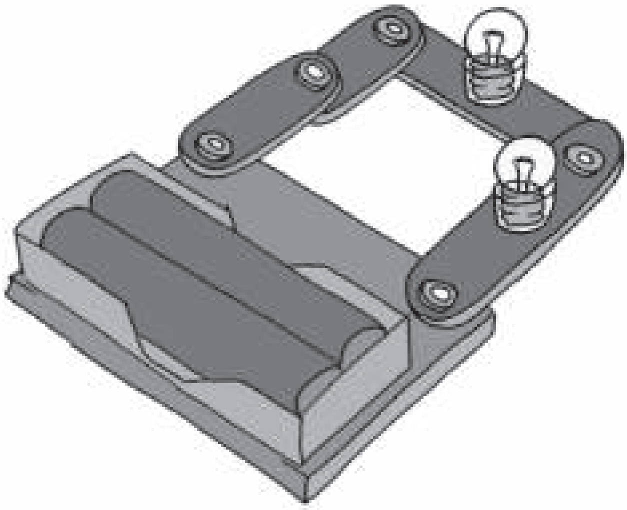
Note:

____

____

____

____



Why does none of the light bulbs emit light? **Nr. 15**

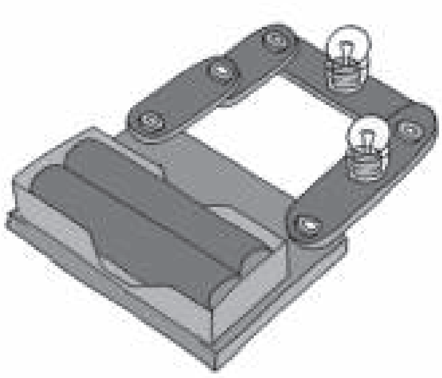
You have unscrewed one of the light bulbs, but all the others go out at the same time. What are you thoughts on this? Note:

____

____

Imagine the right bulb is damaged.
Find the way the current takes in the drawing and mark it in colour.

When one of the lamps is damaged, the circuit is
- ○ closed.
- ○ open.

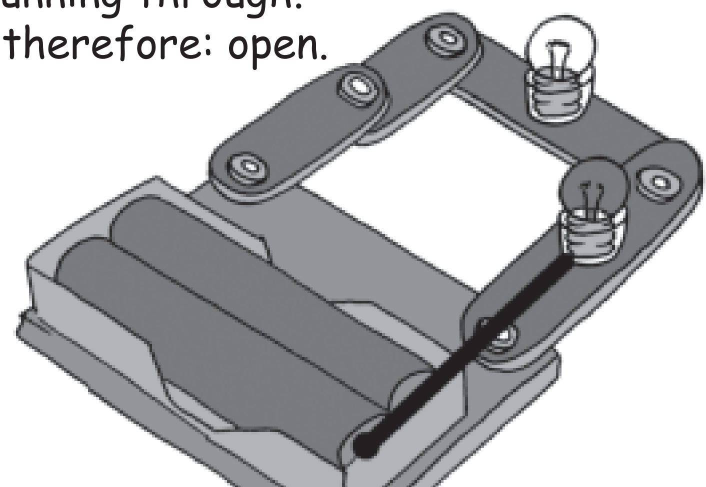


The current
- ○ goes round in a circle.
- ○ does not go round in a circle.

That is why none of the lamps emits light. **Nr. 16**

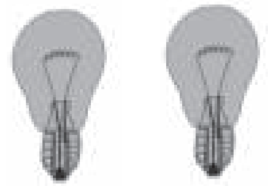
If one of the lamps is damaged current cannot flow through the circuit anymore.
then there is no more current running through.
The circuit is INTERRUPTED – therefore: open.
The current cannot flow in a circle any more.

The other light bulbs do no longer receive any current. Therefore, none of them emits any light.



How can 2 lamps be installed, so that both emit light of equal brightness?

Nr. 17

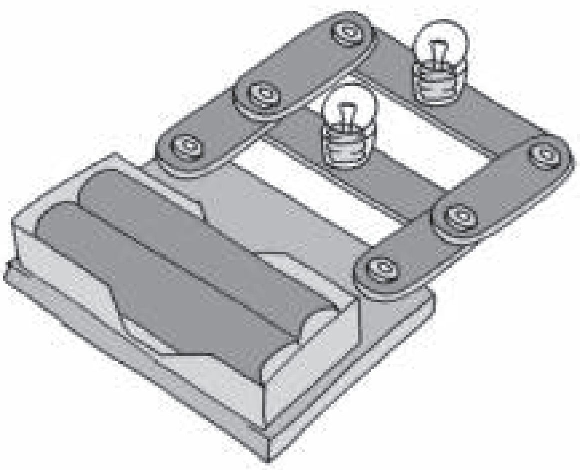


All the light bulbs are supposed to emit light of the same brightness.
Try out several possibilities.
Draw a circuit diagram and mark the position of the bulbs:

Parallel Connection

Nr. 18

Did you connect your light bulbs in a similar way?

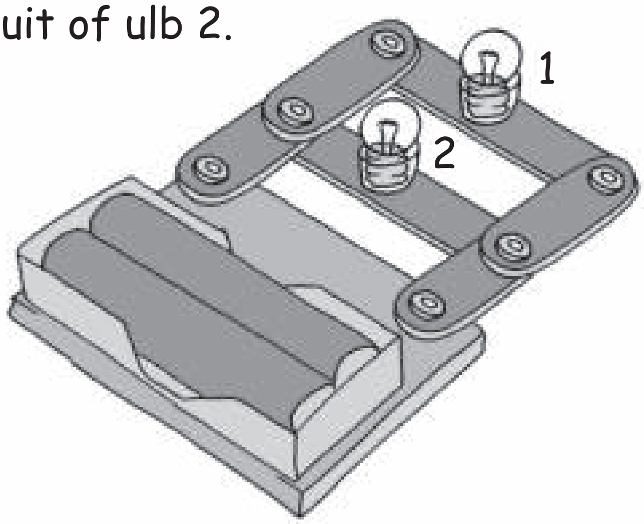


Every light bulb has its own electric circuit. That is why it is called a PARALLEL CONNECTION.

If one of the lights is damaged, or if you unscrew it, the other one continues to emit light.

Which way does the current flow? **Nr. 19**

Trace the circuit of the bulb 1 in the drawing and mark it in colour.
Use a different colour to trace the circuit of ulb 2.



What happens if you remove one of the bulbs?

Note:

____

____

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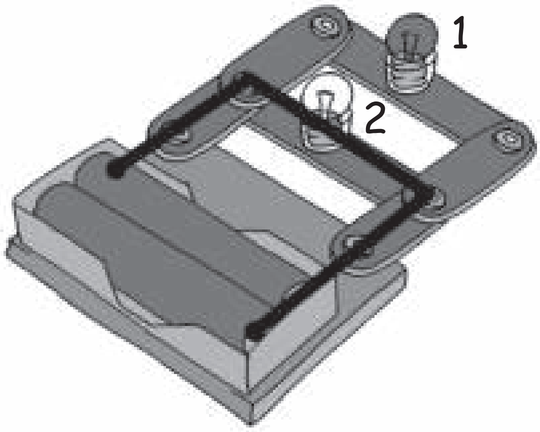
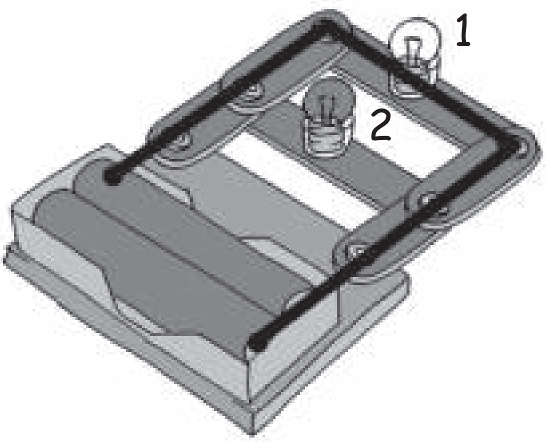
Broken light bulb - it doesn't matter! **Nr. 20**



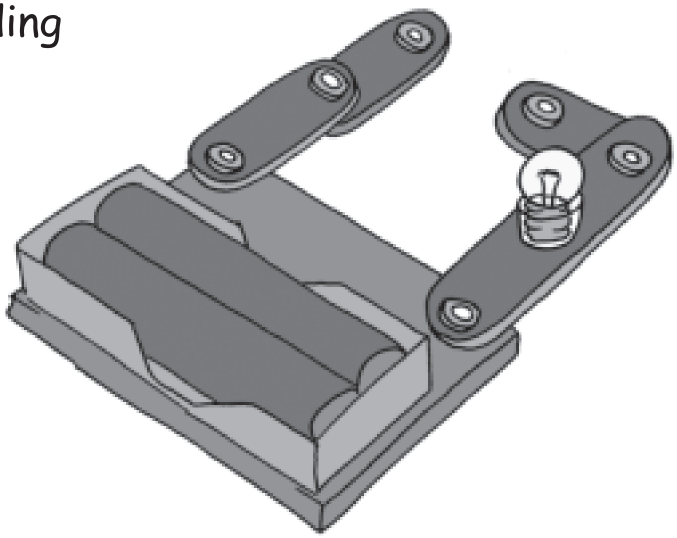
If one light bulb is broken, or if you unscrew it, the other bulb continues to emit light, because every light bulb has its own electric circuit. The two drawings on the left show the circuits of the two light bulbs.



If bulb 2 is broken, the current flows as shown in the bottom drawing.

If bulb 1 is broken, the current flows as shown in the top drawing.

A break in the electric circuit **Nr. 21**



Construct an electric circuit including batteries as shown in the drawing.
Does the bulb light up?

○ yes ○ no

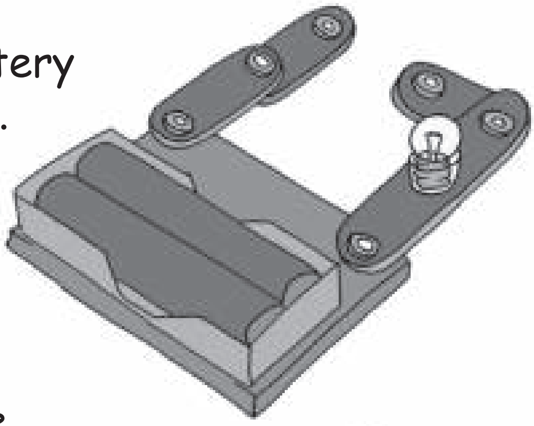
Why is that so? Explain!

____

____

____

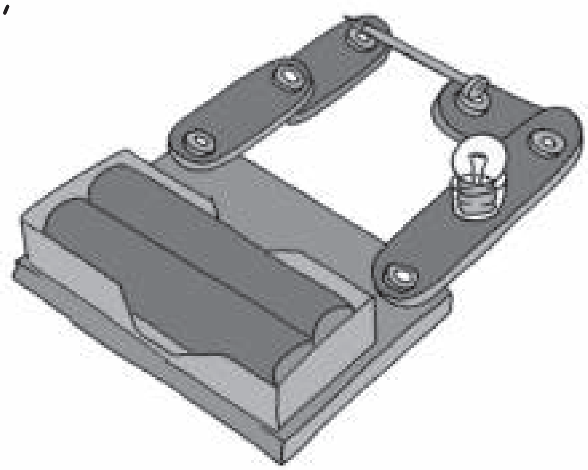
A break in the electric circuit -1- **Nr. 22**



Construct an electric circuit with a battery and a light bulb as shown in the drawing.

Bridge the break with different materials from the construction case, or else find yourself some objects like a rubber, a paper clip, a coin, a nail, a match, a piece of elastic band, a stone, tissue, finger ...

You will surely find even more!



A break in the electric circuit -2-

Nr. 23

What happens when you bridge the break? Assume first!

Object	Material	Assumption: Is the lamp lit?	Observation: Is the lamp lit?
Ruler	Plastic		

A break in the electric circuit -3-

Nr. 24

When you bridge the break with certain materials the lamp emits light.
How do you explain that?

____

____

Which materials make the light bulb emit light?

____

____

With some materials the light bulb does not light up.
How do you explain that?

____

____

Which materials do not make the light bulb emit light?

____

A break in the electric circuit: Conductors and non-conductors

Nr. 25

When you bridge the break with certain materials the lamp emits light.
Current flows through these materials.
It is said that these materials conduct current.
They are called conductors.

With some materials the light bulb does not light up. There is no current flowing through these materials. It is said that these materials do not conduct any current at all or hardly any current. They are called non-conductors or insulators.

Our skin also conducts current but very badly. When it is wet, it conducts the current better.

What do we need insulators for?

Conductors and non-conductors

Nr. 26

Conductors

Current flows through these materials:

Metals
iron, copper, silver, chrome, gold, aluminium, brass, stainless steel.

Other materials too, are conductors:
Water, coal, and graphite.

They are used to:
Give electric current to electronic devices in order to make them work. The current is flowing to the device in cables.

Non-conductors – insulators

These materials do not conduct current:

dry wood, air, porcelain, textiles, glass, plastic.

They are used to:
Make it possible for you to touch the cables that lead the current. Non-conductors protect us from current.

Current is active – current causes an effect **Nr. 27**

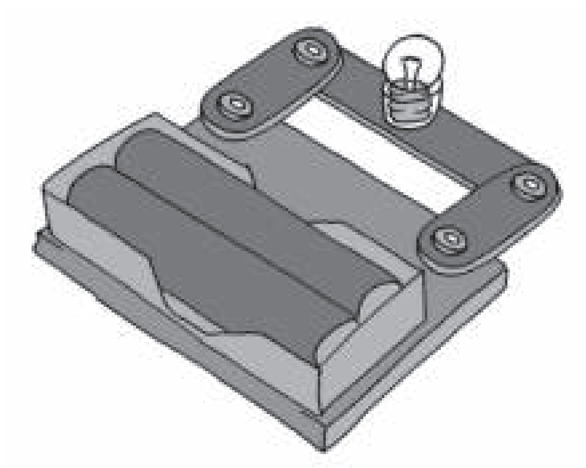
Which devices at your home work with electric current?

What does the current do to these devices?

Device	What the current does
Lamp	Light
Stove	

Current causes an effect -1- **Nr. 28**

Build an electric circuit with a light bulb and a battery.



What does the current cause?

____

____

____

Current produces light -1-

Nr. 29

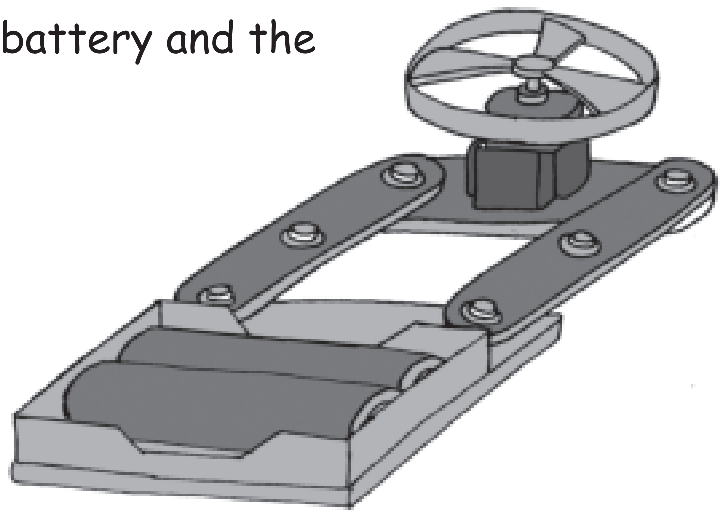
When electric is current flows through light bulb, it generates light.

Which electrical devices do you know where current mainly produces light?
Draw or name at least five devices.

Current causes an effect -2-

Nr. 30

Build an electric circuit using a battery and the motor with the propeller.



What does the current cause?

Current produces movement -2- Nr. 31

When electric is current flows through a motor, it generates movement. Which electrical devices do you know where current mainly produces movement?
Draw or name at least five devices.

____

____

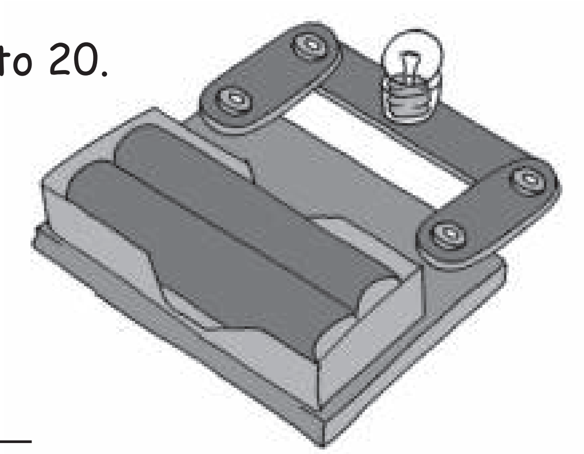
____

Current causes an effect –3 – Nr. 32

Build an electric circuit using a light bulb and a battery.

Touch the light bulb, and count slowly up to 20.
What do you feel?

What does the current cause?



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Current produces heat -3-

Nr. 33

When electric current flows it also generates heat.

Which electrical devices do you know where current mainly produces heat?
Draw or name at least five devices.

____

____

____

Importance of current

Nr. 34

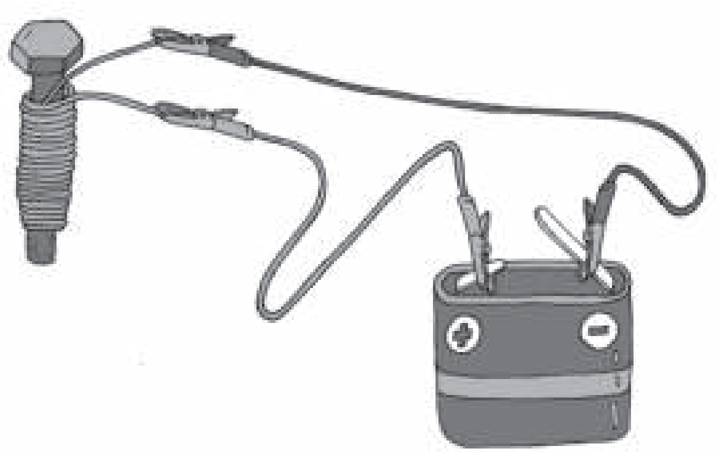
Imagine that overnight, aliens made all our electricity disappear.

What would a normal day be like?
Write at least one page.

Current produces magnetism -4-

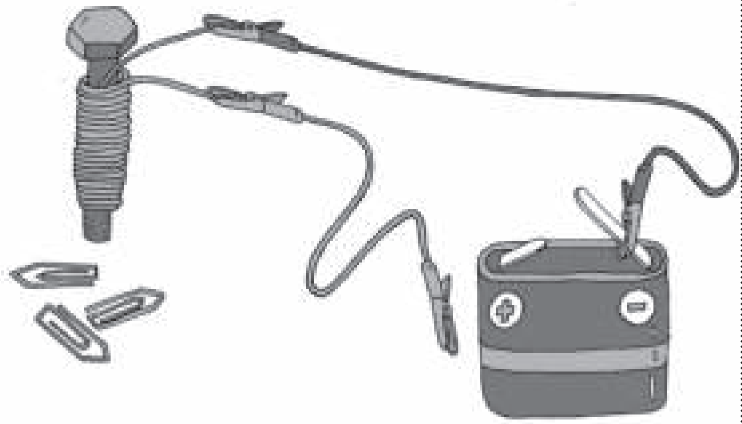
Nr. 35

When electric current flows, a magnetic field is created around the conduction. This magnetic field can be amplified by winding the wire like a spool.



That is called an electromagnet.
An electromagnet
is only magnetic when there is current flowing through the wire.

When the electric circuit is open, there is no current flowing through the wire. The wire is not magnetic. The paper clips fall down.



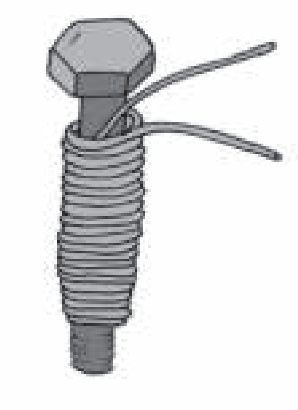
Current causes an effect -4- **Nr. 36**

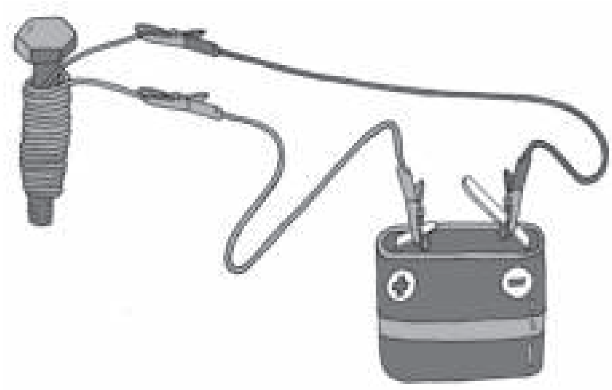
You need: a bolt, wire, a flat type battery, 2 cables with alligator clips, paper clips.

This is how it works:

Let‘s go:

1. Wind the wire very tightly around the bolt!
2. Connect the 2 cables with the alligator clips to the end of the wire.
3. Connect the other ends of the cables to the battery.





Test 1:
The electric circuit is closed.
What happens when you hold the paper clips close to the screw?

Test 2:
Remove one cable from the battery. The circuit is now open and there is no current flowing.
What happens when you hold the paper clips close to the screw?

Attention !

The wire heats up after some time!

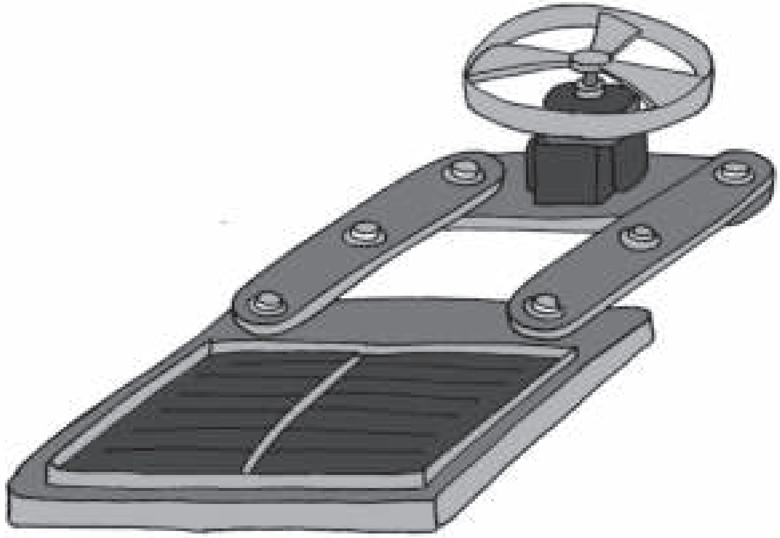
You can get burnt!

What does the solar cell do? -1-

Nr. 37

Build an electric circuit using a solar cell and the motor with the propeller.

What do you observe?



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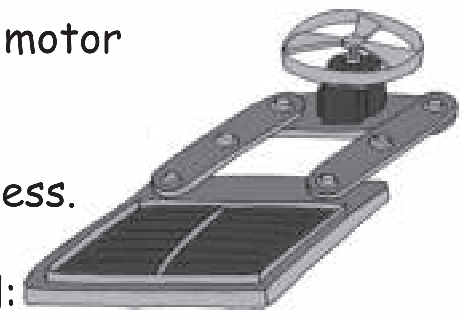
What does the solar cell do? -2-

Nr. 38

Build an electric circuit using a solar cell and the motor with the propeller.

Hold the solar cell into light of different brightness.



What do you observe when you hold the solar cell:

____

...into the sunshine? ____________________

____

...into the shadow? ____________________

____

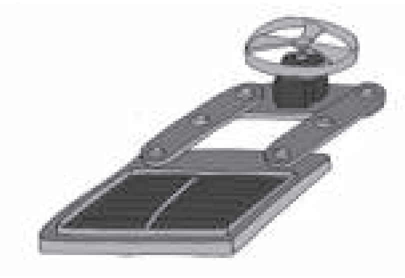
____

What does the solar cell do? -3-

Nr. 39

Mark your answer with a cross!

The propeller moves when I hold the solar cell ...



- ○ into the sunlight
- ○ into the shadow
- ○ into the dark

Solar cells generate electric current. That is why the propeller moves. When do solar cells produce electric current?

When I hold the solar cell
- ○ into the sunlight
- ○ into the shadow
- ○ into the dark

Solar cells need:
- ○ Light in order to be generate electric current.
- ○ Shadow
- ○ Darkness

Do solar cells only work with sunlight? -1-

Nr. 40

Build an electric circuit using a solar cell and the motor with the propeller.

Hold the solar cell into different light sources, i.e. the ceiling light, a torch, the sun ...

Light source	My assumption: The propeller...		Observations
	turns	does not turn	
Sun			
Ceiling light			
Torch			

Do solar cells only work with sunlight? -2-

Nr. 41

Solar cells produce electric current:

○ only with sunlight
○ with other light too.

This made me understand:

____

____

____

When does a solar cell produce a lot of current?
When does a solar cell produce little current?
Where do you see that?
Try to come up with another test yourself.

Or else, use the card: When does a solar cell produce a lot of/ little current?

When does a solar cell produce a lot of/ little current? -1-

Nr. 42

When I hold the solar cell close to the lamp, the propeller moves

○ fast
○ slow

When I move the solar cell away from the lamp, the propeller moves

○ faster and faster
○ more and more slowly

With lots of light the solar cell produces: ○ lots of current
○ little current

With less light the solar cell produces: ○ lots of current
○ little current

This made me understand:

____

____

When does a solar cell produce a lot of/ little current? -2-

Nr. 43

Build an electric circuit using a solar cell and the motor with the propeller.

Hold the solar cell close to a lamp.
Slowly move the solar cell away from the lamp.

Assume, what will happen:

____

____

Perform the experiment, and note your observations!

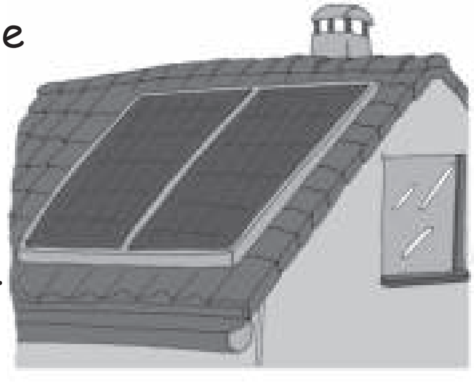
____

____

The solar cell

Nr. 44

Solar cells produce electric current from light.
The type of light is of no importance. There is only one certain type of lamps, where the solar cells do not produce current. These are called LED lamps.
With lots of light the solar cells produce a lot of current.
With only a little light, the solar cells only produce little current. With no light, the solar cells produce no current.
The propeller shows whether the cell is producing a lot of or little current. When the propeller rotates fast, the solar cell creates a lot of current. When the propeller turn slowly, the solar cell creates little current.



Solar roofs can be seen on top of many houses. They produce current which is used up by the household.

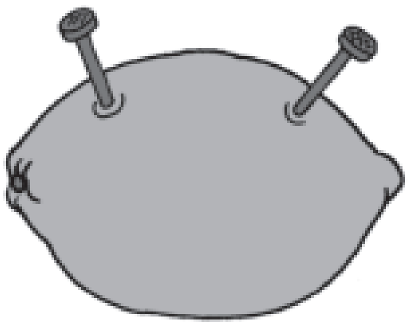
The Fruit Battery

Nr. 45

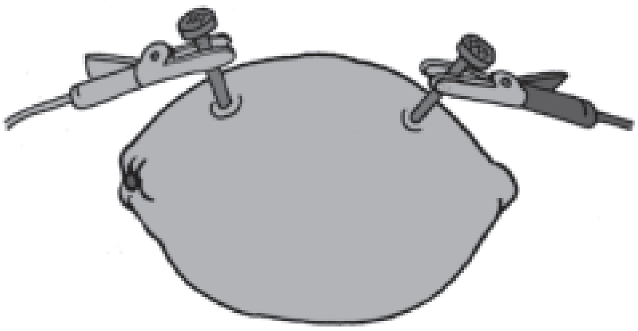
You need: A lemon or another citrus fruit
A copper nail
An iron nail
Two cables with alligator clips
An ammeter or a multimeter

This is how it works:

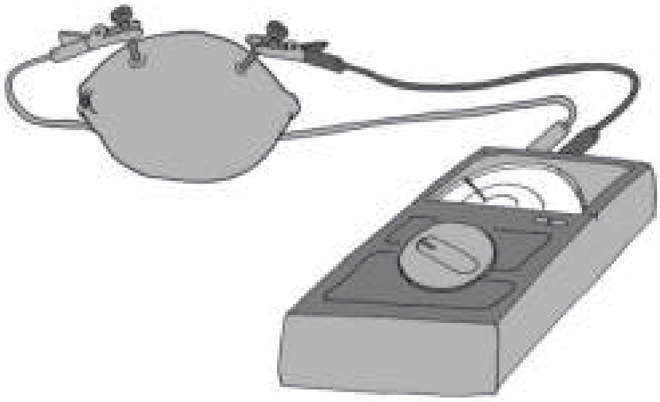
1. Insert the copper nail and teh iron nail into the lemon. Make sure they do not touch.



2. Connect each nail with an alligator clip to a cable..



3. Connect the two other ends of the cables to the contacts of the ammeter.



After the experiment the fruit cannot be eaten any more!

Write down your observations!

____

____

With a citrus fruit you can ○ produce current
○ produce no current

Construction box: Electric Current

Guidance for No. / Part 81937

This guidebook contains experiments and master copies on the following subjects.

- Components of a light bulb
- Open circuit
- Closed circuit
- Switch
- Series connection
- Parallel connection
- Conductors and non-conductors
- Effects of electric current
- Significance of electric current in daily life
- Construction of a simple electromagnet
- Construction of a fruit battery
- Solar cells
- Dangers of electric current

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