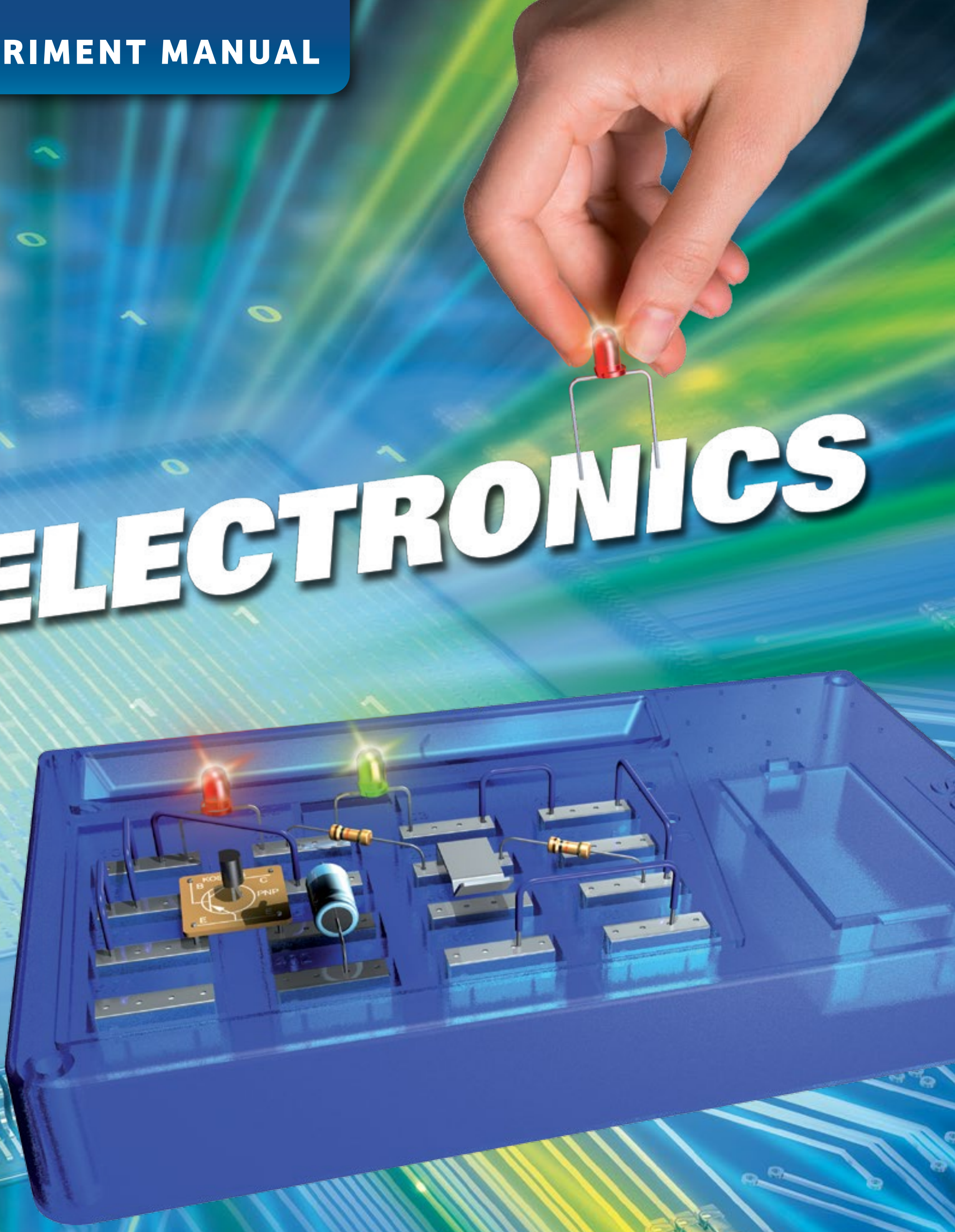
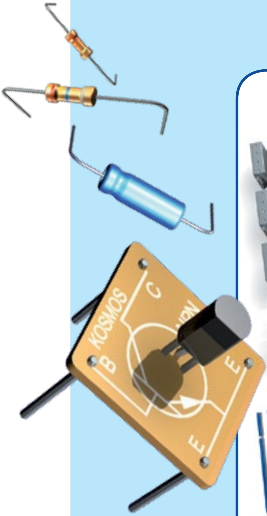
EXPERIMENT MANUAL

ELECTRONICS

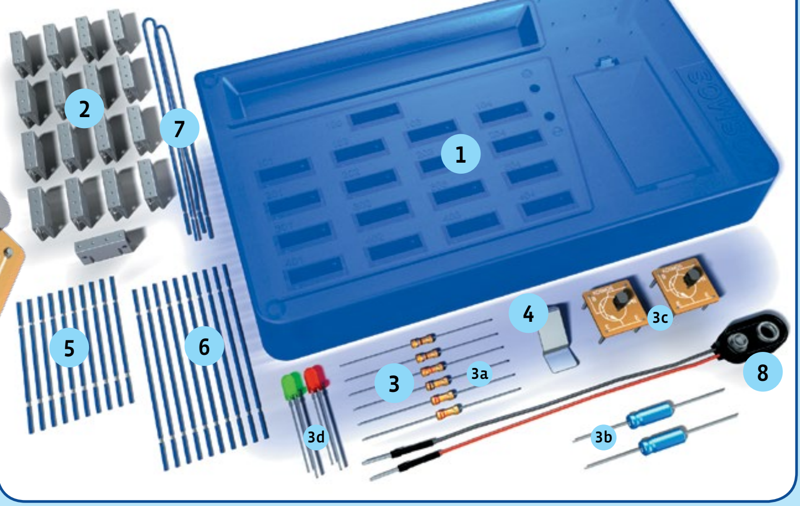


THAMES & KOSMOS

WARNING — Science Education Set. This set contains chemicals and/or parts that may be harmful if misused. Read cautions on individual containers and in manual carefully. Not to be used by children except under adult supervision.



What's in your experiment kit:



Checklist: Find – Inspect – Check off

✔	No.	Description	Qty.	Item No.
☐	1	Electronics board	1	774090
☐	2	Contact clips (17 pieces)	1	000642
☐	3	Electronic components	1	774100
		– Resistor, 470 Ohm	(2)	
		– Resistor, 3.3 Kiloohm	(1)	
		– Resistor, 22 Kiloohm	(1)	
		– Resistor, 100 Kiloohm	(1)	
		– Resistor, 220 Kiloohm	(1)	
		– Electrolytic capacitor, 10 Microfarad	(1)	
		– Electrolytic capacitor, 100 Microfarad	(1)	
		– Transistor module, npn	(2)	
		– Light-emitting diode (LED), green	(1)	
		– Light-emitting diode (LED), red	(1)	
☐	4	Pushbutton	1	000367
☐	5	Wire bridges, short (10 pieces)	1	000282
☐	6	Wire bridges, long (10 pieces)	1	000292
☐	7	Wire connectors	2	000343
☐	8	Battery clip (for 9-volt battery)	1	712310

Please check all the parts against the list to make sure that nothing is missing. If you are missing any parts, please contact Thames & Kosmos customer service.

Additional things you will need:

- → 9-volt battery (Type 6LR61)
- → Drinking glass
- → Blotting paper
- → Tape
- → Glue
- → Scissors
- → Paper
- → Cardboard
- → Pencil
- → Various objects (e.g., bowl, eraser, pencil, toy)
- → Adhesive bandage
- → Aluminum foil
- → Hair dryer
- → Ice
- → Water

CONTENTS

CHECK IT OUT

You will find supplemental information on pages 21, 27, 22, 23, 41, 47, and 48.

Dear Parents,

This experiment kit will introduce your children to the world of electronics with the help of lots of fun and exciting experiments.
Please stand by your child's side during the experiments and be ready to provide advice and assistance.
Before beginning the experiments, read through the manual along with your child. Pay attention to the adjacent safety notes and follow the advice provided with the instructions.
Please be sure that none of the kit parts get into the hands of young children.

We wish you and your child a lot of fun with the experiments!

Safety Notes

WARNING! Only appropriate for use by children at least 8 years of age. Instructions for parents or other supervising adults must be followed.

Save the packaging, as it contains important information!

- **You will need a 9-volt square battery of type 6LR61 for the experiments. Due to its limited shelf life, the battery is not included in the kit and must be purchased separately.**
- **Never perform experiments using wall outlets or the household current supply. Never insert wires or other parts into wall outlets! Household voltage can be deadly.**
- **Do not use batteries together with the household power supply.**
- **Avoid short-circuiting the batteries while experimenting — they could explode!**
- **Never connect the battery terminals to each other.**
- **Remove dead batteries from the kit box.**
- **Dispose of used batteries in accordance with environmental guidelines.**
- **Only install batteries in the correct polarity direction.**
- **Never recharge non-rechargeable batteries. They could explode!**
- **Take rechargeable batteries out of the experiment kit box before recharging them.**

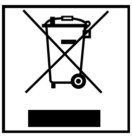
We assume no liability against any damage of any kind that may arise from the experiments. In addition, we offer no guarantee that the circuits and procedures described in this manual are free of copyright protection. The instructions and the materials in the kit are for instructional purposes only, not for professional or practical application.

Used Batteries

What should you do with dead batteries? Do not under any circumstances simply throw them into the trash! For the sake of the environment, you should always take them to a collection location for used battery disposal. Some stores that sell batteries will also accept used batteries for proper disposal.

Advice about protecting the environment

None of the electrical or electronic components in this kit should be disposed of in the regular household trash when you have finished using them; instead, they must be delivered to a collection location for the recycling of electrical and electronic equipment. The symbol on the product, instructions for use, or packaging indicates this.



The materials are reusable in accordance with their designation. By reusing or recycling used devices, you are making an important contribution to the protection of the environment. Please consult your local authorities for the appropriate disposal location.

Note!

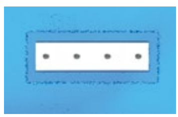
Once you have attached the clip to the battery, do not let the two ends of the wire touch each other — that would result in a short circuit!

The battery could overheat and cause damage. Of course, it would also quickly go dead. Ideally, insert the two wire ends into two contact clips when they are not being used.

Introducing the components

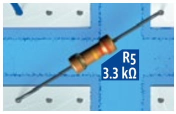
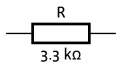
In electronics, components such as resistors, capacitors, light-emitting diodes, and transistors are used.

To understand how all of these components work, you should start by reading through the descriptions below.

Component	Illustration	Pictorial Representation	Schematic Symbol
Contact clips			None

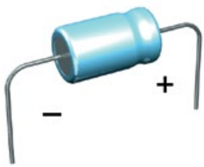
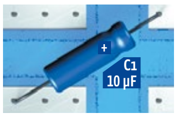
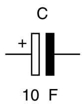
You will need something to hold the electronic components in place while performing the experiments.
In electronics, you usually work with a base plate, sometimes called a breadboard or simply “board.” The electronics board in your kit will serve this purpose. It contains openings for the contact clips and for forming the circuit assembly.

You will be inserting the components into these contact clips in order to connect them to one another electronically.

Component	Illustration	Pictorial Representation	Schematic Symbol
Resistors			

In electronics, it's a common problem that there might be too much current flowing — which can be dangerous for certain electronic components. Light-emitting diodes — miniature electronic lights — can overheat, for example, and be destroyed if they get too much current. That's why you need resistors, which act like little "current brakes." Their ability to put the brakes on current is indicated in ohms (Ω) and kilohms (kΩ). The more ohms a resistor has, the greater its braking effect. You can tell how large a resistor is by looking at the little colored rings printed on the component.
The various resistors in your kit can be distinguished as follows:

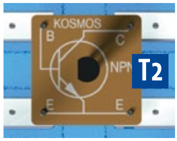
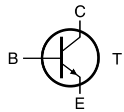
- → **470 Ω yellow-violet-brown**
- → **3.3 kΩ orange-orange-red**
- → **22 kΩ red-red-orange**
- → **100 kΩ brown-black-yellow**
- → **220 kΩ red-red-yellow**

Component	Illustration	Pictorial Representation	Schematic Symbol
Electrolytic capacitors			

Capacitors are able to store electric current, just like a battery. Their capacitance, or how much current they can store, is indicated in "farads." Usually, though, 1 farad is much too much. That's why you typically work with a much smaller unit of measure, the "microfarad" — one millionth of a farad! The abbreviation for microfarad is "µF" (with that first symbol being the Greek letter "mu," short for "micro" or "one millionth").

In this kit, you will find a 10-µF capacitor and a 100-µF one. The capacitance value is printed directly on it. For your experiments, you will be using so-called electrolytic capacitors, which have a plus and a minus mark.

Note: The electrolytic capacitors always have to be installed the right way around, exactly as shown in the circuit diagram.

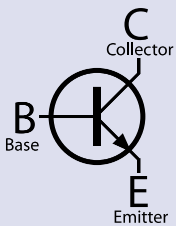
Component	Illustration	Pictorial Representation	Schematic Symbol
Transistor Module			

Transistors are used for switching and amplifying electrical currents and voltages. Each of the two transistor modules in your kit has three terminals:

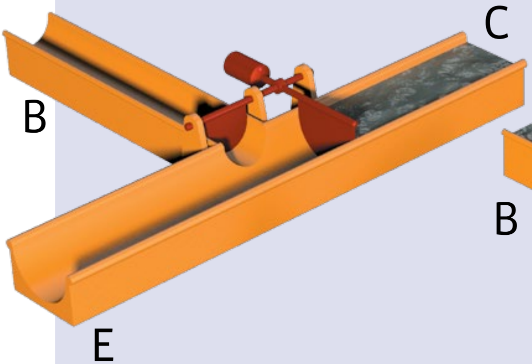
› Collector (C)

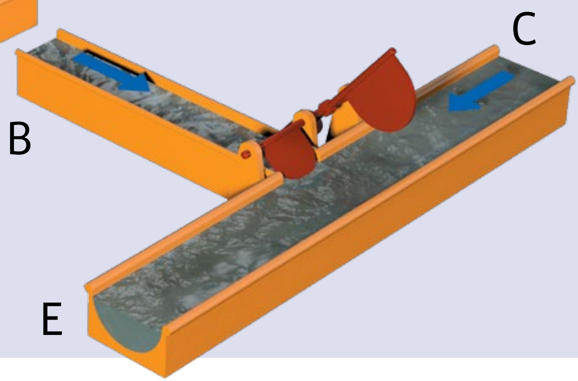
› Base (B)

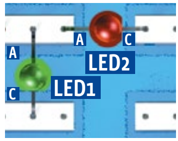
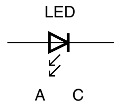
› Emitter (E)

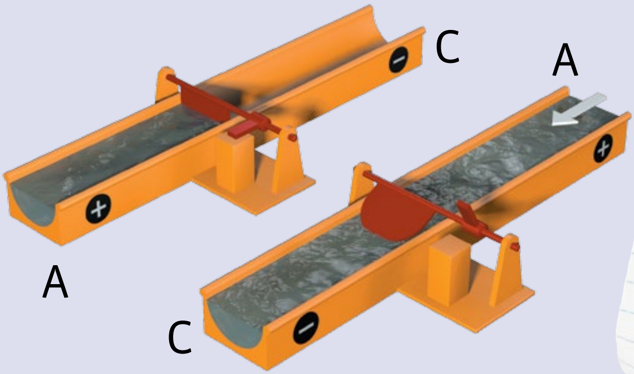


Always be sure to insert the sensitive transistor the right way around — exactly as shown in the circuit diagram!
You can understand the way a transistor works by picturing a model with gates that are controlled by water: First, no water flows in base channel B (corresponding to the transistor's base terminal), meaning no current flows, with the gate at the collector (C) staying shut and blocking the path of the water to the emitter (E). If water does flow in the small base channel (B), then the gate at the collector terminal opens up and a current flows from the collector (C) to the emitter (E) that is much stronger than the base current (B)!
So now the transistor is switched on, and current flows between the collector (C) and the emitter (E).
The transistor is not just capable of turning on and off, though. It can also become more or less conductive. It can use smaller current to influence larger ones, which can be used to amplify small signals.
In the model, we can picture that as small waves in the base channel turning into larger ones in the collector-emitter channel.





Component	Illustration	Pictorial Representation	Schematic Symbol
Light-emitting diodes			



Safety note

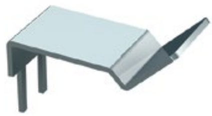
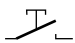
Never hold light-emitting diodes directly against a battery to see whether they light up. They would immediately break!

Light-emitting diodes, or LEDs for short, are small, sensitive components used to signal a switch state. For example, an LED will let you see whether a piece of equipment is switched on or whether an alarm has been triggered. LEDs have terminals of two different lengths. The shorter one is called a cathode (C), and the longer one is an anode (A).

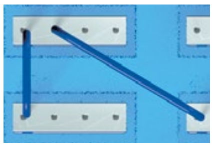
LEDs and other diodes have two different poles, meaning that they only work in one direction. When turned the wrong way, they won't let current through and they also won't light up.

Diodes work similarly to the model with the water and the gate. If the current comes from the wrong direction, the mechanism prevents the water from flowing through.

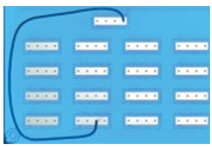
If the water comes from the other direction, the gates open up and the water flows through. That corresponds to an LED with its poles turned the right way.

Component	Illustration	Pictorial Representation	Schematic Symbol
Pushbutton (tactile switch)			

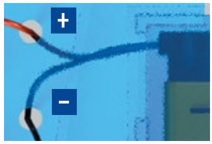
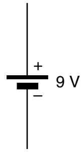
The pushbutton is a kind of current switch, serving to open or close a circuit. A regular switch will open or close a current flow and keep it in that state. A pushbutton, on the other hand, will open or close the circuit just briefly, releasing a kind of "signal" in the process.
This signal is understood by the circuit as a kind of order, such as "Set the alarm!"

Component	Illustration	Pictorial Representation	Schematic Symbol
Wire bridges			

The wire bridges are made of thin copper wire, which is a good current conductor. They connect the other kit components by way of small contact clips, thus conducting the current from one component to the next.

Component	Illustration	Pictorial Representation	Schematic Symbol
Wire connectors			

You will find two additional long wire connectors in your kit. You will be using them as sensors and alarm wires, for example.

Component	Illustration	Pictorial Representation	Schematic Symbol
Battery clip			

Without electricity, electronics cannot function at all. The electricity for your experiments will be supplied by a 9-volt (9 V) square battery, which is not included in the kit. You will have to get one.
Batteries lose their power after they have been stored a while. So if a battery were to be included in the kit, it might not have its full power when you purchased it — and it wouldn't be good for anything.
The battery clip will help to conduct electrical current from the battery to your circuit. It is easily mounted onto the battery, with only one orientation being possible relative to the battery terminals. The current will then move through the two loose wires to your circuit.

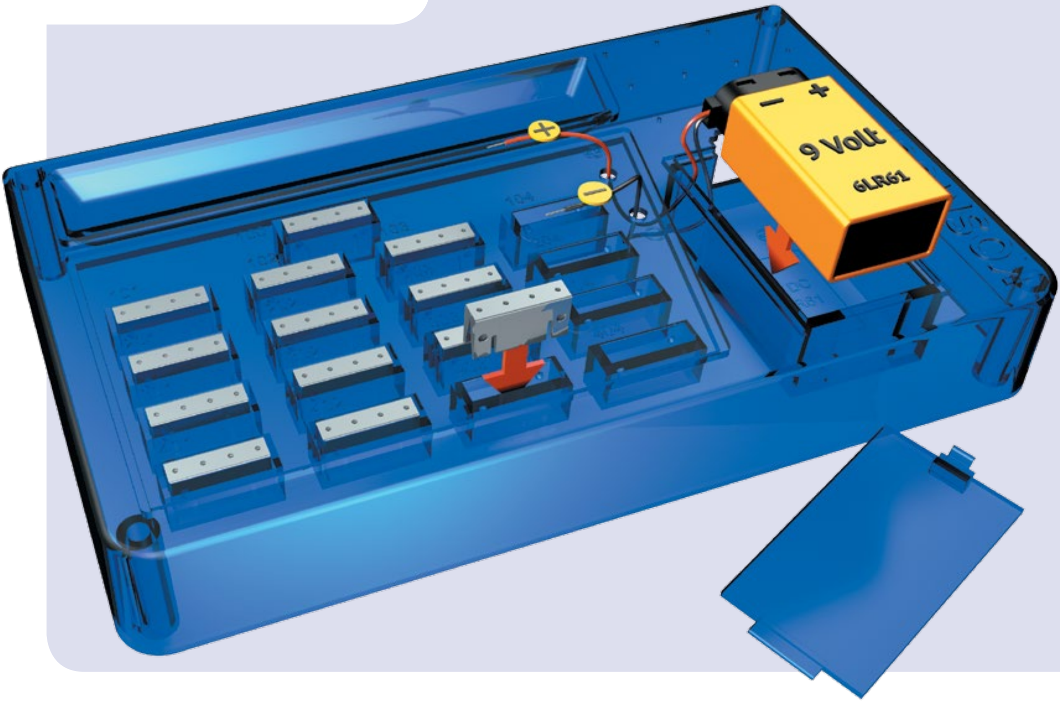
Safety note
Never connect the terminals of a battery directly to each other — the battery might explode!

Getting ready for the experiments

Before you can actually start, there are still a few preparations you have to take care of. One is to mount the contact clips onto your board. You will also have to insulate off the wire sections and bend them into the right shape. The LEDs will have to be prepared before inserting them in the contact clips, too.

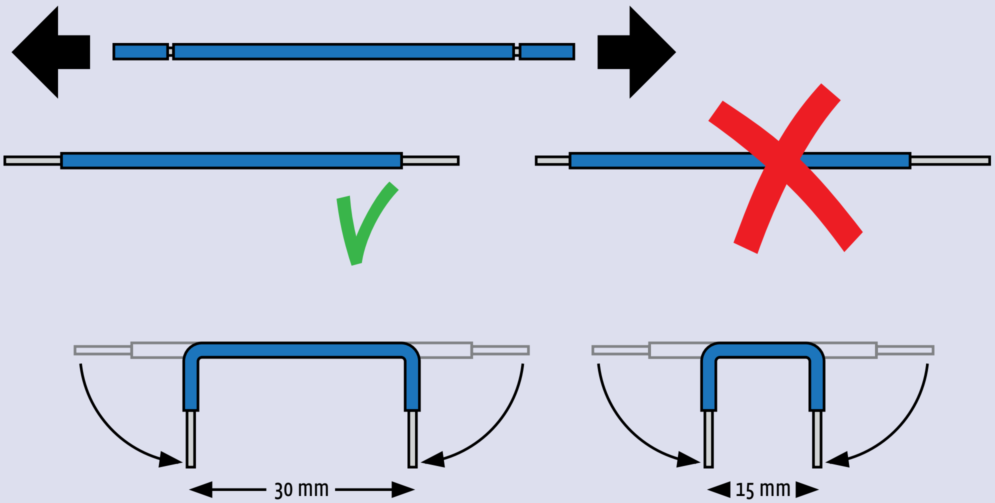
Mounting the contact clips

In order to assemble an alarm system or a lie detector, you will have to be able to connect the individual components to one another. That is what the contact clips are for. These are small, highly conductive metal parts with holes in the top. You can insert the components' terminal wires or connecting wires (the wire bridges) into the holes and pull them out again easily. Your kit contains 17 contact clips to insert into the board. It's easy. Just hold the sides of the contact clip between thumb and forefinger and press them gently together. Then, simply insert the sides into the openings. When you insert the clip, be sure that the side with the holes is always toward the top. If there are components that you don't need right away, you can keep them in the top compartment and the recesses to the right. The battery goes in the compartment next to the area with the contact clip openings.



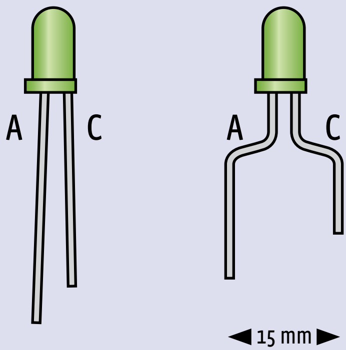
Preparing the wire pieces

Take a careful look at the short and long wire pieces. You can see that the wire is surrounded by a thin layer of plastic, know as “insulation.” The insulation prevents current from being conveyed to your body, for example, if you accidentally touch the wire. There are cuts through the insulation near both ends of the wire, forming loose sleeves that you can easily slide off, leaving bare wire ends behind. The two bare wire end sections should be equally long, as shown in the picture below. Then, you will still have to bend the wire pieces into shape. To do that, place them so they fit exactly on top of the sketch, and bend them as shown:



Bending the LED terminal wires

You will also have to bend the LED terminal wires to be able to insert them into position later on. To do that, proceed just as you did with the wire bridges: Place the LED on top of the sketch to the right, and bend the wires as shown in the drawing. Please note that one of the LED terminals is shorter than the other. This helps to tell them apart, which is important because the LEDs will only light up if they are installed in the right direction.

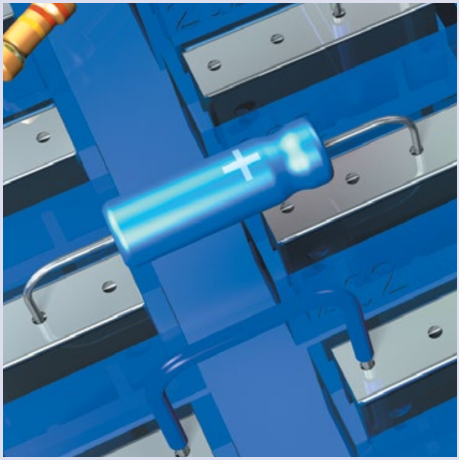


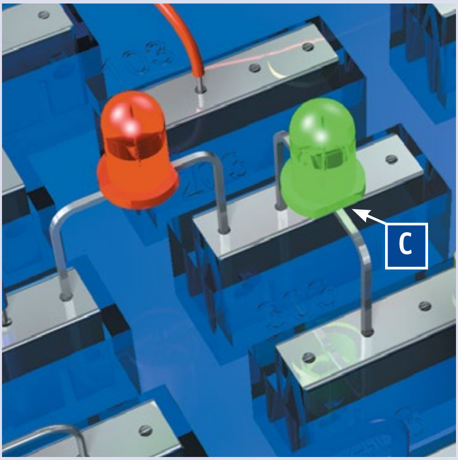
Getting everything ready

At the beginning of each experiment, you will find an overview of all the components that you will need. So start by looking for all the parts and placing them in the parts compartment.

The right polarity is important!

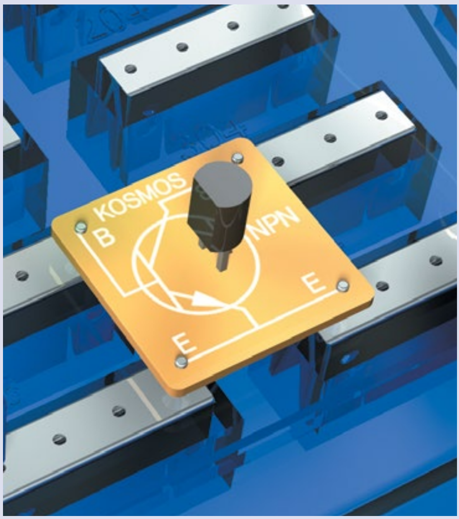
Always install the capacitors the right way around! The assembly drawing shows exactly how. Also be sure to use the right capacitance value, 10 µF or 100 µF. Otherwise, the circuit won't work right.





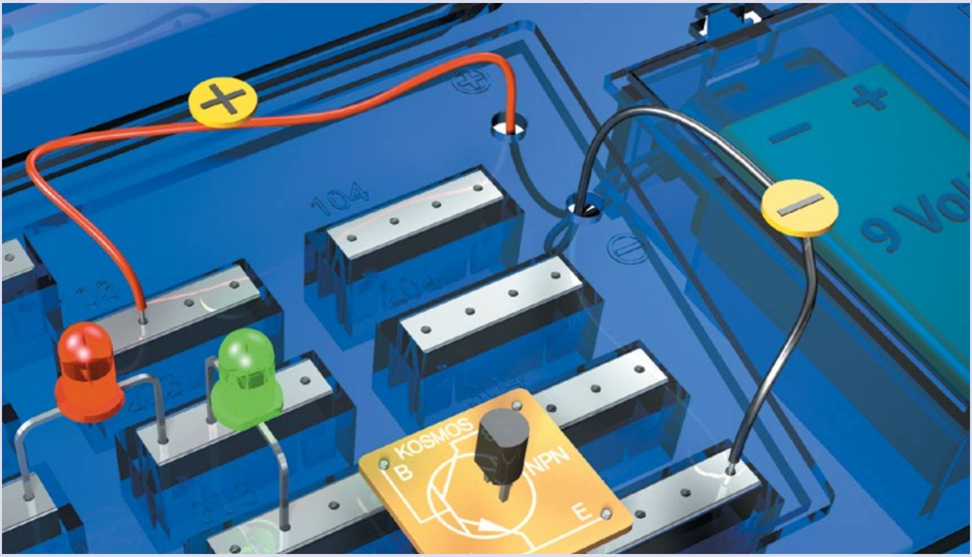
Insert the transistor module

You always have to install the transistor correctly, too. All of the assembly drawings are oriented so the "E" (emitter) terminal is at the bottom, never at the right, left, or top.



Insert the LEDs correctly

The LEDs have one long and one short terminal wire. The short terminal (the cathode) is indicated with a "C" in the drawings, and the longer one (the anode) is indicated with an "A." In addition, the cathode side of the LED is flattened.

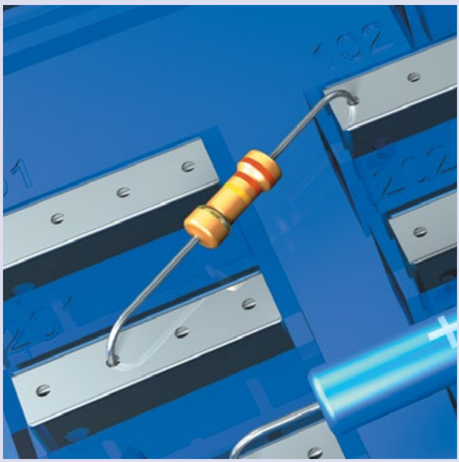


Pay attention to the wire colors

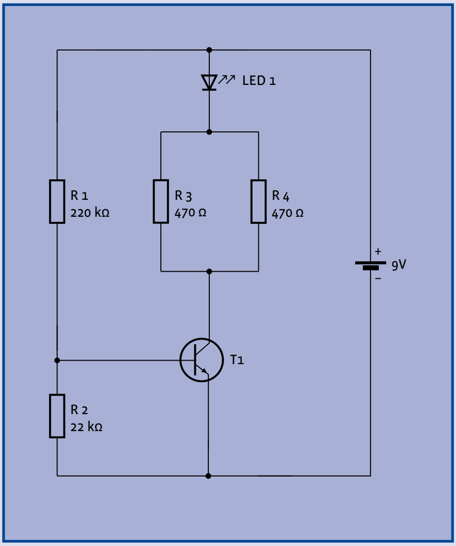
The current always has to flow in the right direction. It can only do that if you attach the battery terminal wires correctly.
The positive wire coming from the battery clip is red, while the negative wire is black. The same colors are used in the assembly drawing as well.
In the drawing, you will also see a + and a – sign next to the connections.

Using the right resistors

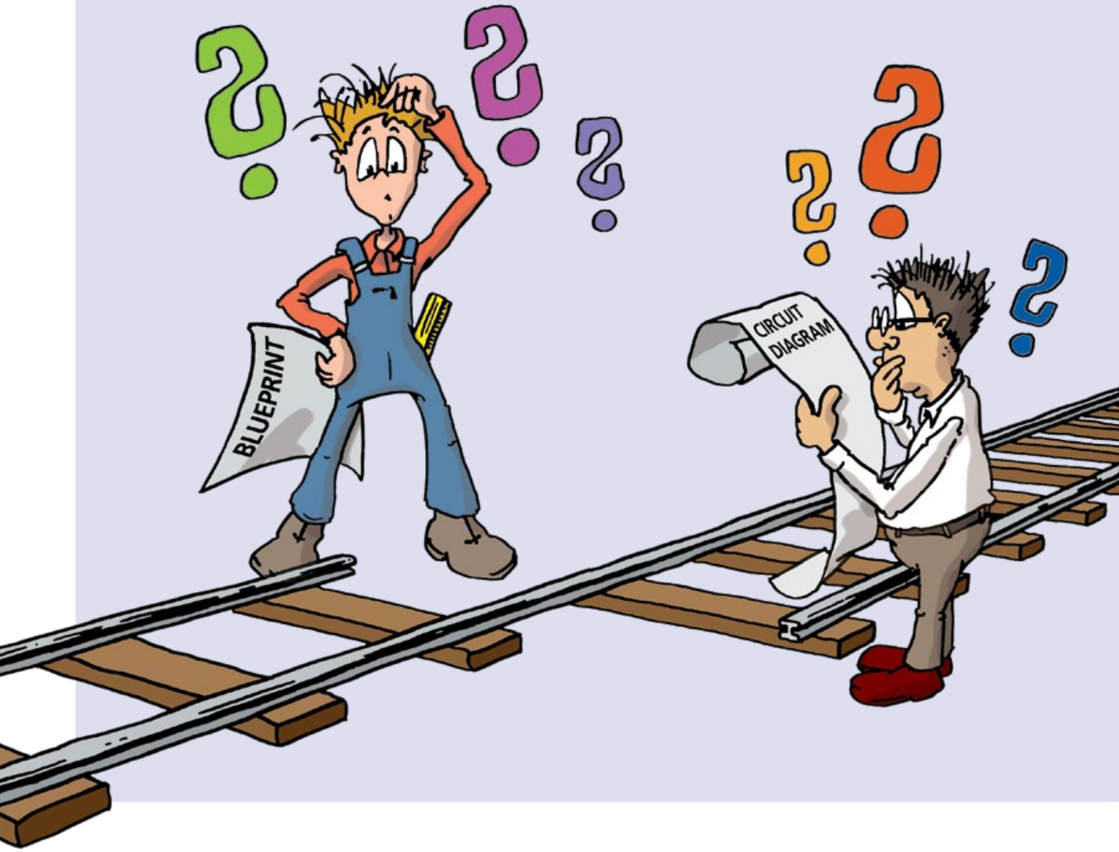
The resistors protect components such as the LEDs against excessive current, which might destroy them. So always be sure to install the right ones.



The circuit diagram



In order to understand how a circuit works, you need a circuit diagram. It uses symbols to represent the individual components and shows how they are connected to one another.
You can check the meanings of the symbols by taking a look at the section with the component descriptions. This kind of schematic circuit diagram is much easier and quicker to draw than a complete circuit board illustration. For each experiment, you will find both a pictorial illustration as well as its corresponding circuit diagram.
As an example, this is the circuit diagram for a battery tester (Experiment 18).

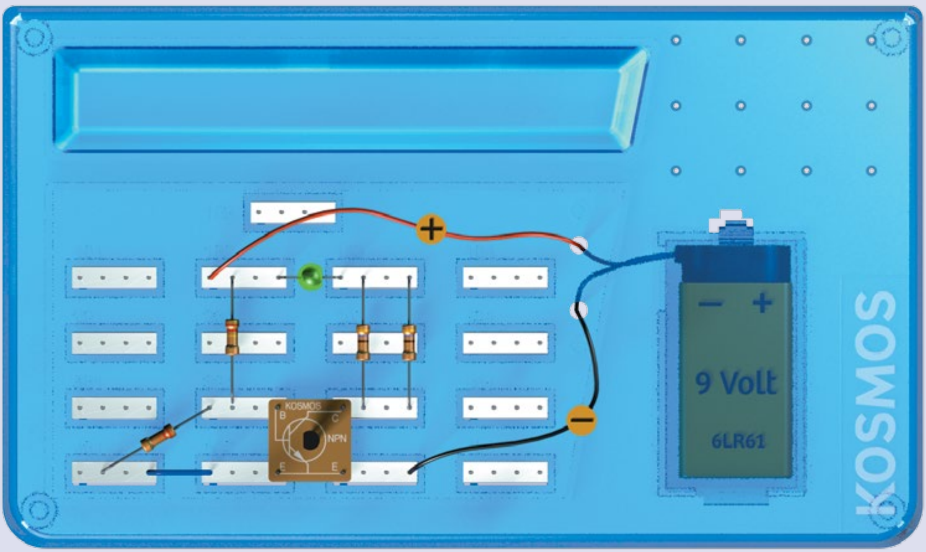


The circuit board illustration

If you have a complicated circuit assembly, a schematic circuit diagram can be quite difficult for a layperson to understand. That is why, in some of the experiments, we also illustrate the board as viewed straight down from above.
In these illustrations, all of the components are shown and labeled exactly as described on pages 2 to 8. So if you ever aren't sure exactly which component you are supposed to use, you can check the front of this manual.

This shows the illustration corresponding to the battery tester (Experiment 18) circuit board on the previous page.

Note!
The colors of the components can sometimes be different from how they are shown in the manual illustrations. This will not affect their function.



Conductance

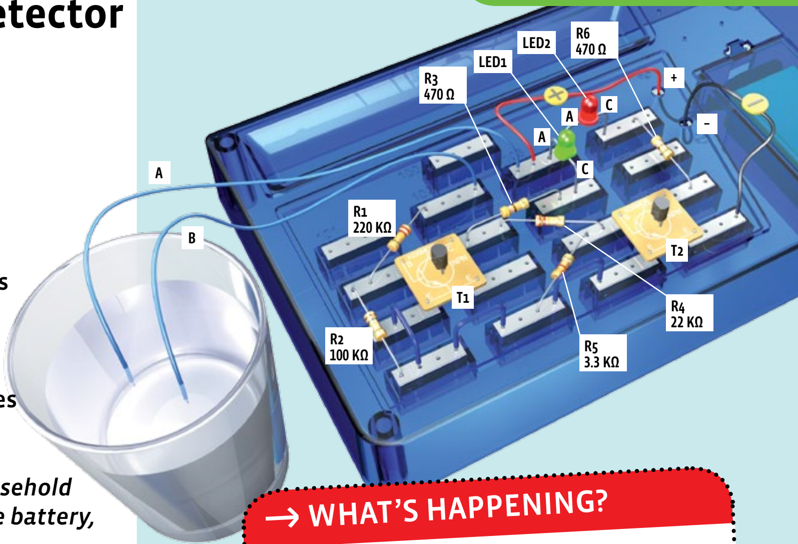
Would you like to know which things are good conductors of electricity and which are not? Then assemble your humidity detector and start by testing the conductance of water.

EXPERIMENT 1

Humidity detector

YOU WILL NEED

→ 2 resistors, 470 Ω
→ 1 resistor, 3.3 kΩ
→ 1 resistor, 22 kΩ
→ 1 resistor, 100 kΩ
→ 1 resistor, 220 kΩ
→ 3 short wire bridges
→ 2 long wire connectors
→ 2 LEDs
→ 2 transistor modules
→ electronics board
→ battery clip
→ *and additional household items: 9-volt square battery, glass of water*



HERE'S HOW

1. Assemble the circuit following the circuit diagram. You will use the loose ends of the two long wires ("A" and "B") as "sensors."

2. Fill a glass with tap water.

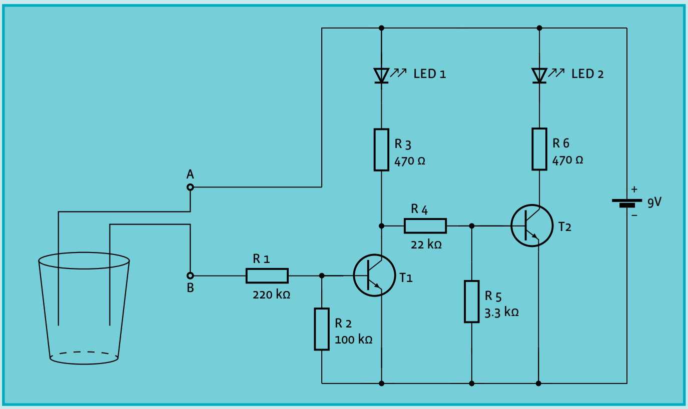
3. Dangle the two long wires A and B into the glass.
What happens?

4. Now pull the wires back out of the glass.

5. Hang the two wires in the water again and wait a couple days.
What happens when the water evaporates?

→ WHAT'S HAPPENING?

As soon as the two long wires touch the water, the green LED lights up — an indication that there's enough water present. If you pull one of the wires out of the glass, the green LED will go out and the red one will come on. The same thing happens, of course, when the water level drops far enough in the glass for the wires to be no longer covered with water. The red LED turns on, in other words, when there's not enough water!



EXPERIMENT 2

Rain sensor

YOU WILL NEED

→ your humidity detector
→ *and additional household items: blotting paper, tape, scissors*

HERE'S HOW

1. Cut a piece of blotting paper about 5 x 10 cm in size and tape it to the outside sill of a window in your room.

2. Insert the bare ends of the long wires A and B of the humidity detector into the blotting paper strip. Now you just have to wait for a good rain.

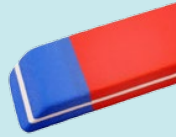
→ WHAT'S HAPPENING?

When it starts to rain, the blotting paper soaks up water and your electronic circuit reacts to the moisture — the green LED lights up.

When the rain stops, the blotting paper dries again, and the red LED comes on.

EXPERIMENT 3

Conductivity tester



YOU WILL NEED

- → **your humidity detector**
- → ***and additional household items such as a key, eraser, coin, pencil, toys***

HERE'S HOW

1. Get the items ready that you will want to test.

2. Hold the two bare ends of the long wires of your humidity detector up to the key, eraser, coin, etc.

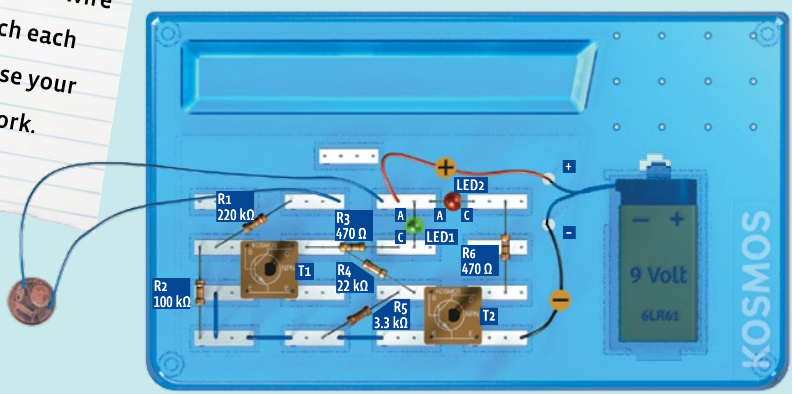
→ WHAT'S HAPPENING?

If the materials are conductive, the green LED will light up; if they do not conduct electricity, the red LED lights up.

So not only can your circuit signal the conductivity of water, it can also show what other objects are capable of conducting current.

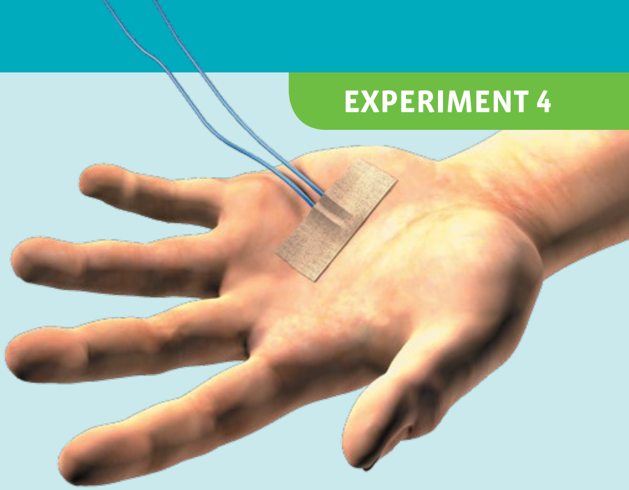
Note!

Of course, during all your experiments you have to be sure that the bare wire ends do not touch each other — otherwise your sensor will not work.



EXPERIMENT 4

Lie detector



YOU WILL NEED

→ your humidity detector
→ *and additional household items: adhesive bandage, test subject* :)

HERE'S HOW

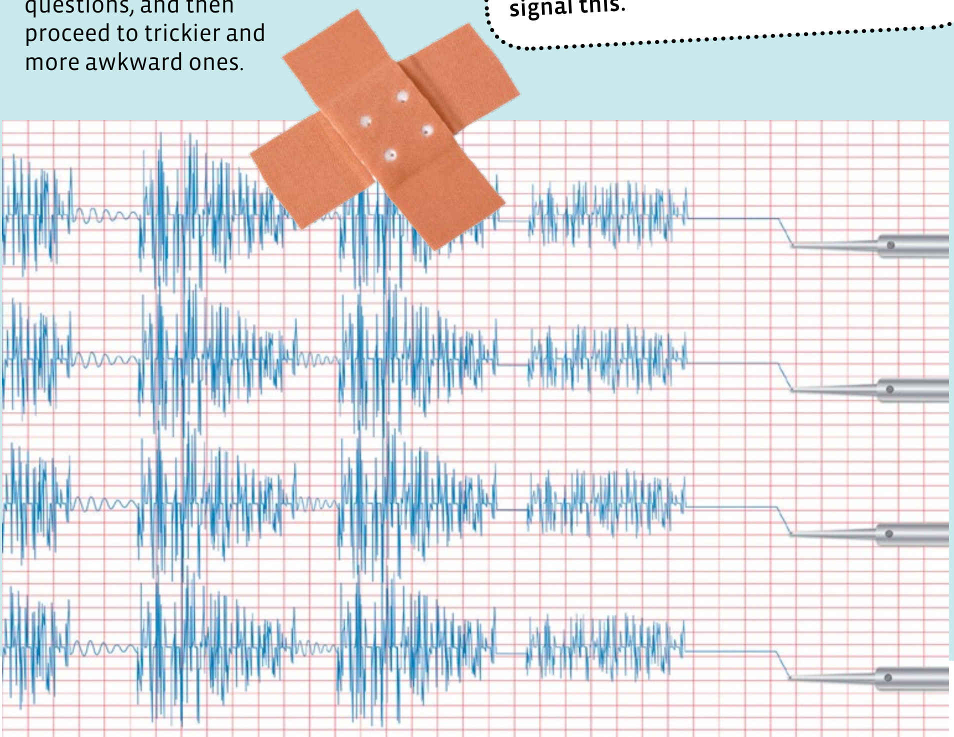
1. Find a test subject and use the bandage to tape the two loose wire ends to the palm of his or her hand. Carefully position the wires so their ends are close to each other but do not touch. Before you start the lie test, the detector's red LED should be lit.

2. Start by asking your test subject some harmless questions, and then proceed to trickier and more awkward ones.

→ WHAT'S HAPPENING?

As long as the red LED stays lit, the test subject is telling the truth. But when the green LED lights up, he or she might be lying.

When people lie, their palms start to sweat. This film of sweat on the palms causes enough moisture to accumulate for your circuit to be able to detect and signal this.



Moisture sensor in the car

CHECK IT OUT

→ Almost every car has an electronic moisture sensor, which serves to detect whether there is enough water in the windshield wiper system.
If the water level drops far enough to leave the moisture sensor "hanging in the air," a diode lights up on the dashboard or the moisture sensor sends a signal to the on-board computer.

Lie detector

→ In everyday language, a lie detector refers to a device that measures and displays bodily signals — such as blood pressure, pulse, breathing rate, or the electrical conductance of the skin — during an interrogation. In technical terms, the device is not called a lie detector, but a polygraph ("multi-writer").

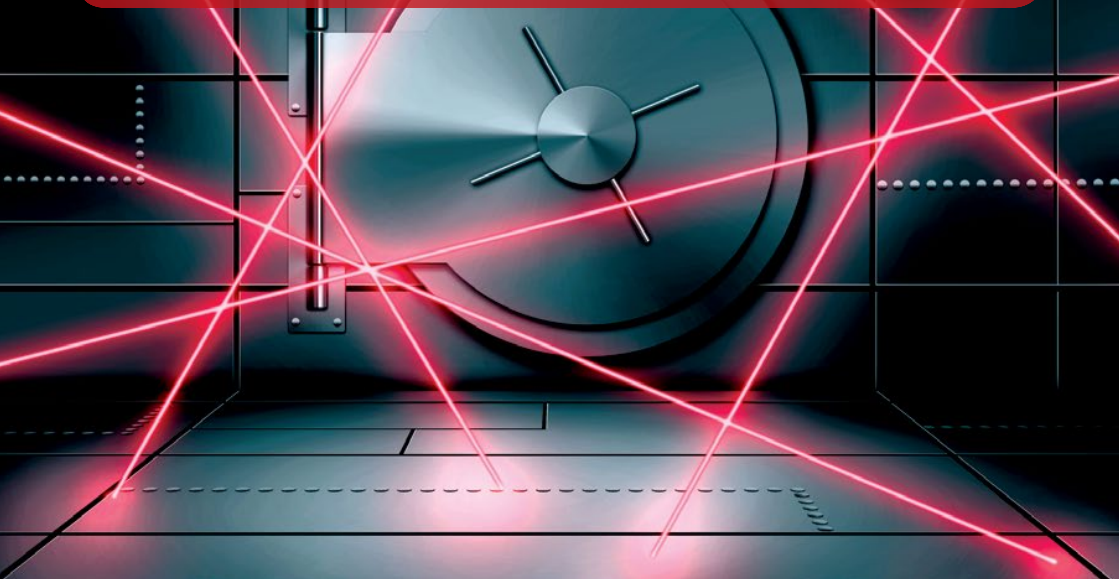
In some countries, lie detectors are not permitted in a court of law, because they only work well with people who are cooperative. Even something as simple as a hand movement can falsify the results, meaning that the recorded reactions will not be typical for a given true or false answer.

Did you know?

If someone seems to be telling something that is wholly or partly untrue, it's common to say something like "Now he's starting to sweat!" Your humidity detector reveals the literal truth behind that saying.

Alarm Systems

Did someone steal your favorite candy bar again? Try building a simple alarm system that you can use to secure your door or window. That way, you will be able to see if someone has been in your room while you were away.

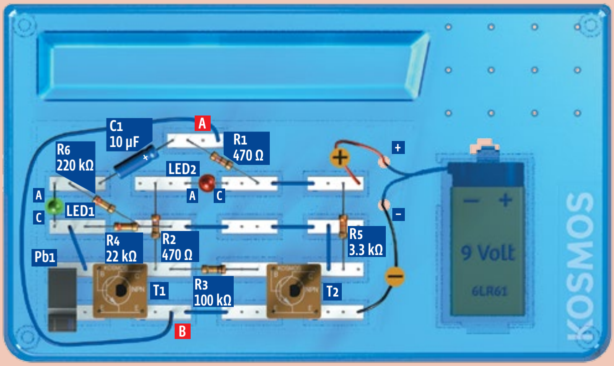


EXPERIMENT 5

Alarm system

YOU WILL NEED

→ 2 resistors, 470 Ω
→ 1 resistor, 3.3 kΩ
→ 1 resistor, 22 kΩ
→ 1 resistor, 100 kΩ
→ 1 resistor, 220 kΩ
→ 1 capacitor 10 µF
→ 2 LEDs
→ 2 transistor modules
→ 1 pushbutton
→ 6 short wire bridges
→ 1 long wire connector
→ electronics board
→ battery clip
→ *and additional household item: 9-volt square battery*



→ WHAT'S HAPPENING?

As soon as the connection between the A and B contact clips is interrupted, the red LED turns on: Alarm! And the green LED only comes on briefly when the alarm is shut off.

HERE'S HOW

1. Assemble your alarm system.

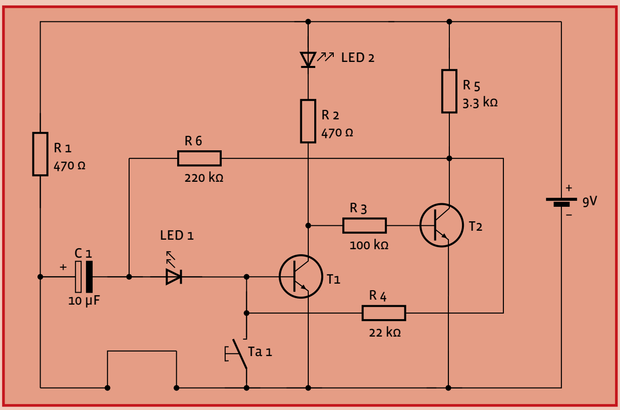
2. Connect the contact clips marked "A" and "B" with a long wire.

3. When you hook up the battery and push briefly on the pushbutton, the red LED (LED2) goes out.

4. The alarm system is now ready for you to test it by pulling the long wire out of the circuit.

Tip

Continue right away to the next experiment.

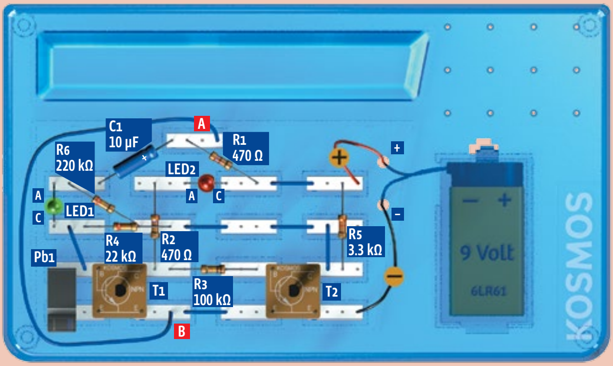


EXPERIMENT 6

Clever alarm system

YOU WILL NEED

→ your alarm system from Experiment 5



HERE'S HOW

Insert the long wire into the alarm circuit again. What do you notice? What do you notice?

→ WHAT'S HAPPENING?

When you re-install the long wire, the red LED won't go out!

You can only cut off the alarm and get the system ready again by pressing the pushbutton. Can you figure out why you might not want the LED to go out again, even when you re-establish the original connection?

The explanation is simple: If that weren't the case, an intruder could simply turn off the alarm himself!

So if, instead of the long wire, you use a thin tripwire that an intruder breaks, it won't do him any good to mend the wire again.

EXPERIMENT 7

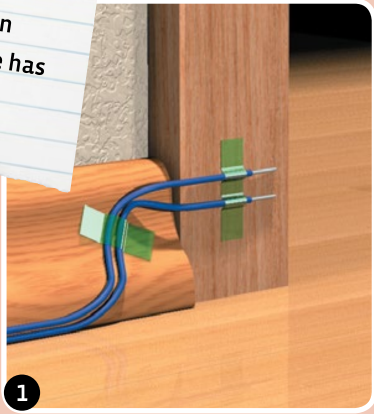
Securing the room door

Tip

Of course, you can also use your alarm system to secure a window. That way, you can always tell when someone has opened it.

YOU WILL NEED

- → your alarm system from Experiment 5
- → 1 long wire connector
- → *and additional household items: 9-volt square battery, aluminum foil (2 x 5 cm), cardboard (2 x 7 cm), tape, glue, scissors*



1

HERE'S HOW

1. To use your alarm system properly, you will need a door contact. To make one, pull the long wire out of terminal A or B and insert another long wire into the now-open terminal. Now lead the two long wires to the doorframe and secure them there with tape.

2. Cut a piece of aluminum foil (around 2 x 5 cm, say) and a slightly longer strip of cardboard (2 x 7 cm). Glue the foil to the cardboard strip.

3. Attach the cardboard with the foil to the door at the same height as the two wire ends that you already attached to the doorframe. Be sure that when the door closes, the two wires from terminals A and B touch the aluminum foil.

4. Open the door and see what happens.

3

→ WHAT'S HAPPENING?

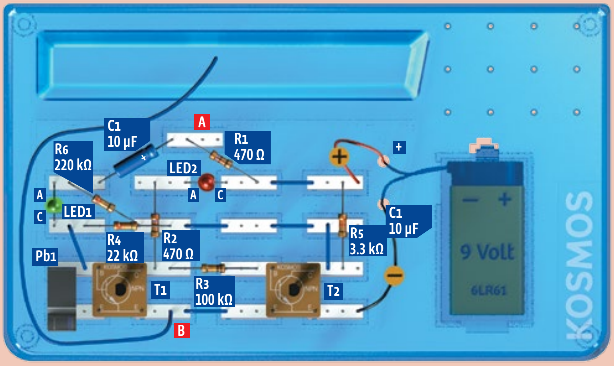
The aluminum foil is a good conductor of current. If the door opens, the flow of current is interrupted — exactly as if you had pulled one of the wires away from the A or B contact clip. Alarm! And since the LED won't go out even if the door is closed again, you can always tell whether someone opened it and went into your room while you were away.

EXPERIMENT 8

Flip-flop circuit

YOU WILL NEED

→ **your alarm system from Experiment 5**



HERE'S HOW

1. Pull the long wire out of contact clip A.
2. Briefly touch the free end of the wire against the base terminal (B) of the right T2 transistor.
   What do you notice?
3. Now press the pushbutton.
   Do you notice a change?

→ WHAT'S HAPPENING?

When you touch B, the LED still lights up. But as soon as you press the pushbutton, the LED goes out. You can repeat this little game as many times as you like. The circuit always remembers the last state — in other words, it stores it.

Flip-flop

Your alarm system is a modified "flip-flop" circuit. A flip-flop is a fully automatic electronic switch of a type that is very often used in electronic equipment — such as in the memory cells of computers.

Well protected

→ Today, electronic alarm systems protect many valuable objects, such as cars, and buildings, such as banks and apartments. A loud siren or a wildly flashing alarm light will usually drive off an intruder pretty quickly, because it attracts a lot of attention.

Intruders can often even be frightened just by seeing that an alarm system has been installed. Holdup alarm systems serve to respond to break-ins or notify a security service or the police in case of a stickup.

CHECK IT OUT

Access control

There are also other methods, though, to deny access to unwanted persons. This kind of system only lets people into a building if they know the right key combination.

In spite of common notions of "night-time visitors," well over a third of all home break-ins happen during the day, when people are away from home at work or school. Most daytime home break-ins happen in cities.

How do real alarm systems work?

→ They operate in pretty much the same way as the system you built: during a break-in, a burglar will trip a hidden switch, which will break a circuit, thereby triggering the alarm. The circuit in an alarm system is called a "zone." Such switches are located around windows and doors. If a burglar opens the window or door, it will sound a siren or an alarm light will go on.

Timer switches

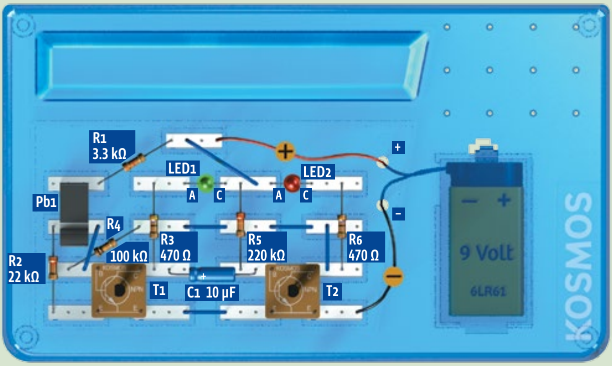
Timer switches can open or close circuits in a delayed manner. What role does an electrolytic capacitor play in this? Perform the experiments in this chapter to find out.

EXPERIMENT 9

Timer switch

YOU WILL NEED

- → 2 resistors, 470 Ω
- → 1 resistor, 3.3 kΩ
- → 1 resistor, 22 kΩ
- → 1 resistor, 100 kΩ
- → 1 resistor, 220 kΩ
- → 1 capacitor 10 µF
- → 2 LEDs
- → 2 transistor modules
- → 1 pushbutton
- → 5 short wire bridges
- → 1 long wire bridge
- → electronics board
- → battery clip
- → *and additional household item: 9-volt square battery*



HERE'S HOW

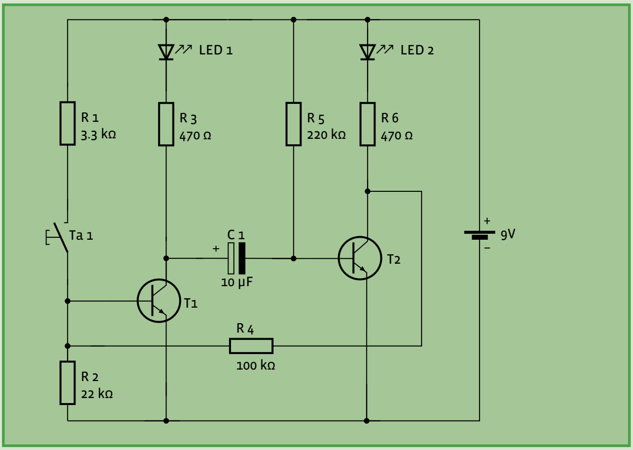
1. Assemble your timer switch and connect the battery. Wait for the red LED to come on and the green one to go out by itself. Now your timer switch is ready!

2. Press once on the pushbutton.

→ WHAT'S HAPPENING?

When you first connect the battery, the green LED is lit up while the red one is switched off. Your timer switch is ready once the red LED comes on by itself and the green one goes out.

As soon as you press the pushbutton, the green LED comes on and the red one goes out. After a cycle time of just under a second, the timer switch returns to its starting state. The cycle time is determined by capacitor C1 and resistor R5.

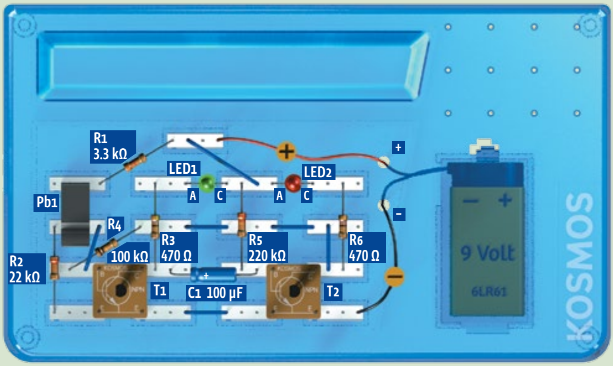


EXPERIMENT 10

Lenghtening the cycle time

YOU WILL NEED

→ your timer from Experiment 9
→ capacitor 100 µF



HERE'S HOW

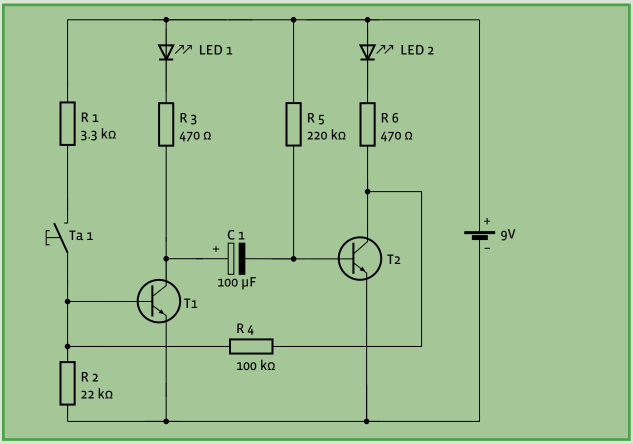
1. Replace the 10-µF capacitor in your timer switch with the 100-µF one.

2. Connect the battery and wait until the timer is ready.

3. Press once on the pushbutton. What has changed since Experiment 9?

→ WHAT'S HAPPENING?

The cycle time is determined by the electrolytic capacitor you install in the switch circuit. Because the newly-installed 100-µF capacitor has ten times the capacitance of the 10-µF one used in Experiment 9, the result is about ten times the cycle time.

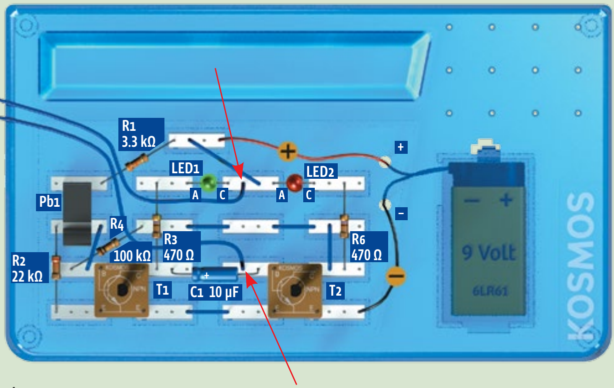


EXPERIMENT 11

Hands as resistors

YOU WILL NEED

→ your timer from Experiment 9
→ 2 long wire connectors
→ 1 capacitor 10 µF



HERE'S HOW

1. Remove the 220-kΩ resistor (R5) and insert a long wire into each of the places where its two terminals were.

2. Take the bare wire ends between your thumb and forefinger of each hand and press the pushbutton with your middle finger (which has the farthest reach). You will see that you act like a large resistor.

→ WHAT'S HAPPENING?

Depending on the dampness of your skin and the pressure of your finger, the cycle time will be shorter or longer. Of course, you can also perform this experiment with the 10-µF capacitor. In that case, you will see that the cycle time is shorter again.

What a timer switch is used for

Timer switches are extremely useful circuits for making life a little more comfortable. Here are a few examples to show you the kinds of things they can do:

- → The inside light of a car should only go out after a certain delay, so you can easily insert your key into the ignition even when it's dark out.
- → An alarm should only come on after a certain delay, so the proper owner has enough time to turn the system off after opening the door.
- → A pedestrian light should only switch from red to green a few seconds after the button has been pushed.
- → To save electricity, stairway lights in apartment houses should only shine for a few minutes before turning themselves off.

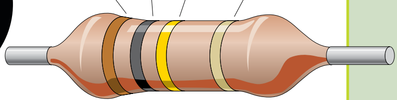
TIMER CLOCKS

A timer clock is a clock that switches an electrical contact on or off at a specified time. The switching times can be individually adjusted. Electronic timer clocks can be used to switch a water system on or off at a certain hour, or example.

CHECK IT OUT

THE RESISTOR COLOR CODE

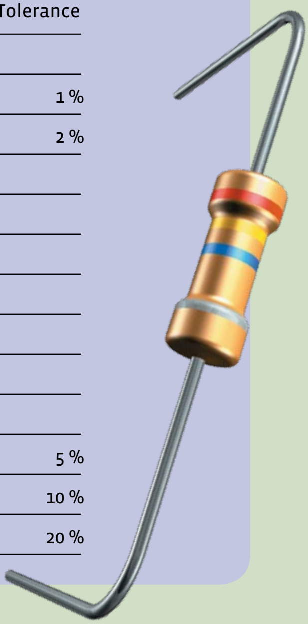
Rather than having their resistor values printed on them in numbers, these tiny components use colored rings. That means that they are easy to read regardless of their orientation.
Depending on their position, the individual rings designate the first or second digit of the number value along with the number of zeros that follow. The table below shows which ring stands for which digit or for the following zeros, and what each color means in terms of numbers.



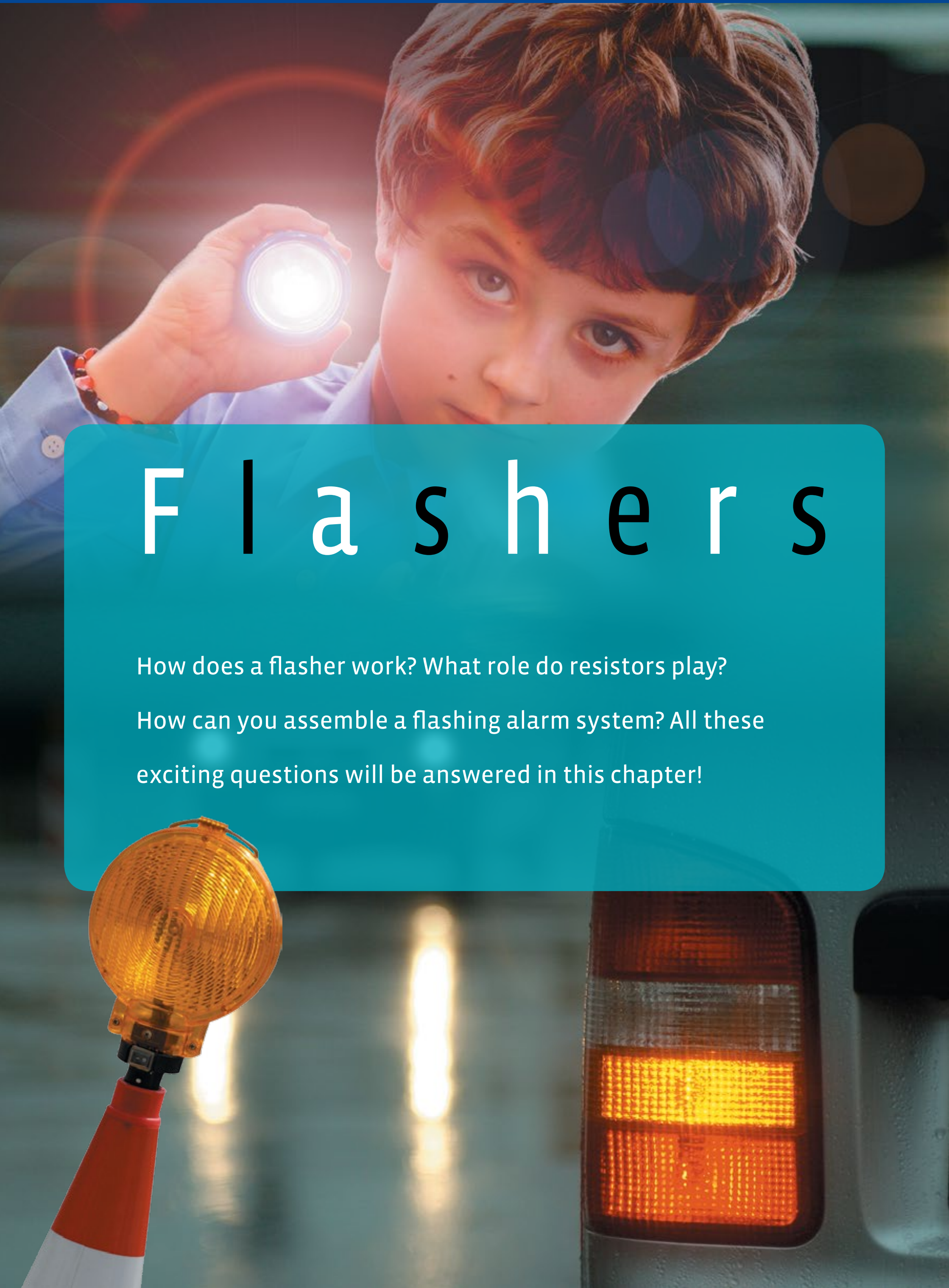
Example: 100 Kiloohm = 100,000 Ohm

Caution:
Note the polarity!

Because the insulation layer of an electrolytic capacitor is produced electrochemically, this component is sensitive to reverse polarity. So you have to be careful to install your 100-µF the right way around — look for the (+) sign!



Color		1st Ring 1st Digit	2nd Ring 2nd Digit	3rd Ring Zeros	4th Ring Tolerance
Black		0	0	-	
Brown		1	1	0	1 %
Red		2	2	00	2 %
Orange		3	3	000	
Yellow		4	4	0 000	
Green		5	5	00 000	
Blue		6	6	000 000	
Purple		7	7		
Gray		8	8		
White		9	9		
Gold				x 0.1	5 %
Silver				x 0.01	10 %
No Ring					20 %



Flashers

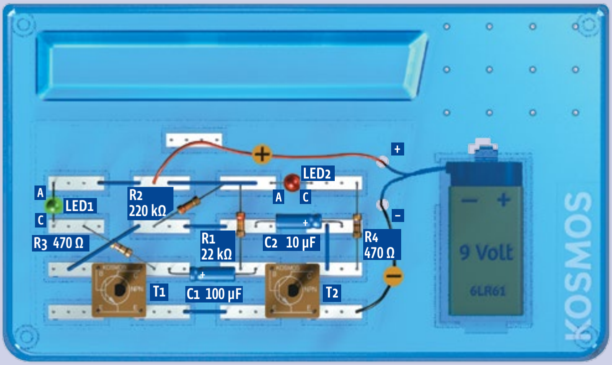
How does a flasher work? What role do resistors play? How can you assemble a flashing alarm system? All these exciting questions will be answered in this chapter!

EXPERIMENT 12

Flasher circuit

YOU WILL NEED

→ 2 resistors, 470 Ω
→ 1 resistor, 22 kΩ
→ 1 resistor, 220 kΩ
→ 1 capacitor 10 µF
→ 1 capacitor 100 µF
→ 2 LEDs
→ 2 transistor modules
→ 4 short wire bridges
→ 2 long wire bridges
→ electronics board
→ battery clip
→ *and additional household item: 9-volt square battery*



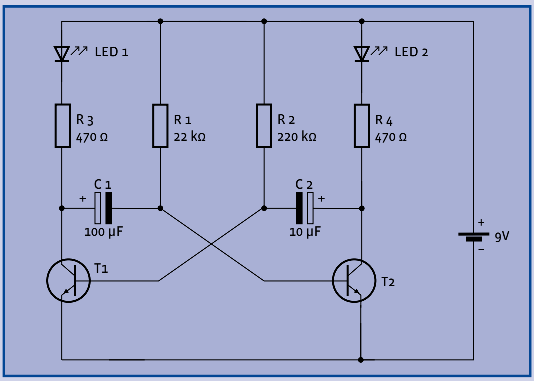
HERE'S HOW

1. Assemble your circuit.

2. Connect the battery and watch what happens.

→ WHAT'S HAPPENING?

As soon as you hook up the battery, the green and red LEDs start to light up in turn — switching quickly every one or two seconds.

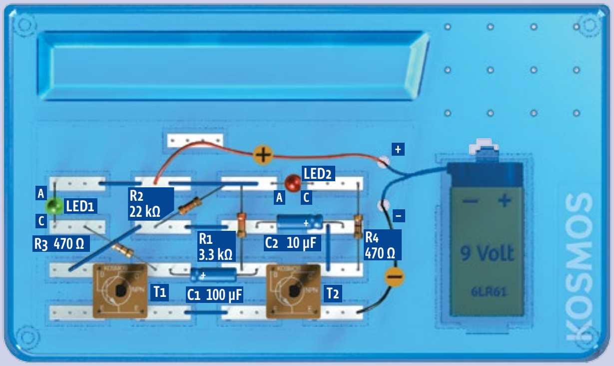


EXPERIMENT 13

Changing the flashing speed

YOU WILL NEED

- → your flasher circuit from Experiment 12
- → 1 resistor, 3.3 kΩ



HERE'S HOW

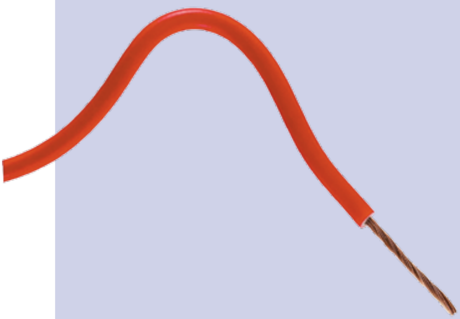
1. Take your flasher circuit from Experiment 12 and remove the red wire from the positive battery terminal. Park it in one of the board's compartments.

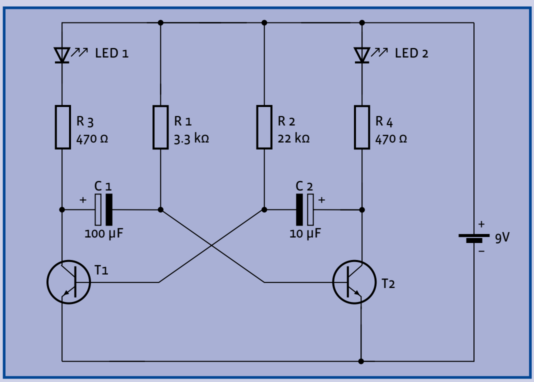
2. Now make the following changes in accordance with your new assembly plan: Remove the 22-kΩ resistor (R1) and the 220-kΩ resistor (R2). In their place, insert the 3.3-kΩ resistor for R1, and the 22-kΩ resistor for R2.

3. Replace the red battery wire.
   What do you notice?

→ WHAT'S HAPPENING?

As soon as you have replaced the red battery wire, the two LEDs flash in rapid succession! So you have shortened the flash duration.



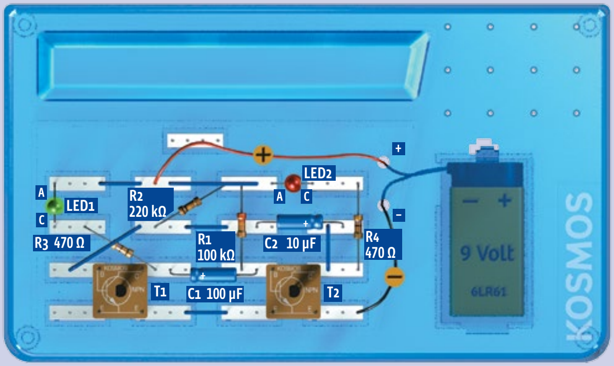


EXPERIMENT 14

Brief blinking

YOU WILL NEED

→ your flasher circuit from Experiment 12
→ 1 resistor, 100 kΩ



HERE'S HOW

1. Remove the 22-kΩ resistor (R1) and replace it with the 100-kΩ resistor. Do you notice something?

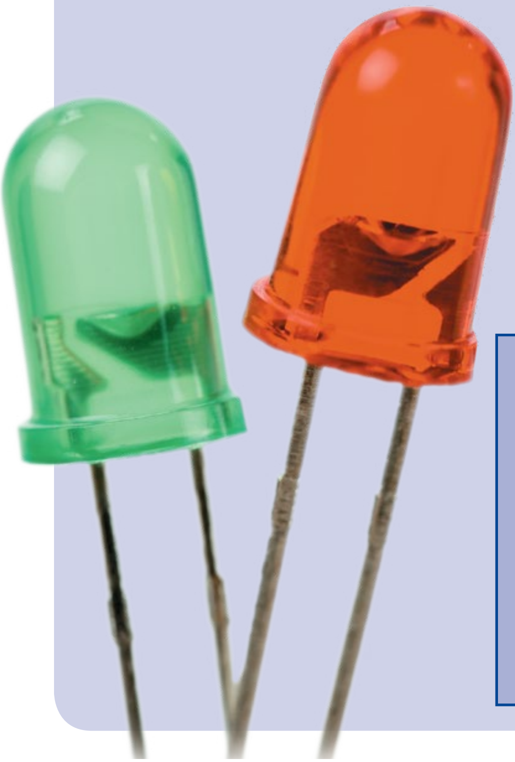
2. Wait a brief moment.

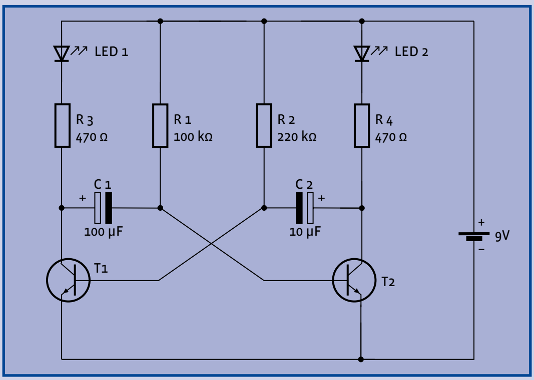
→ WHAT'S HAPPENING?

At first, when you exchange the resistor, nothing happens at all except for the green LED lighting up.

But then the red LED flashes quickly, while the green one briefly goes out!

So, by switching the resistors, you changed the circuit so that the red LED blinks just briefly.



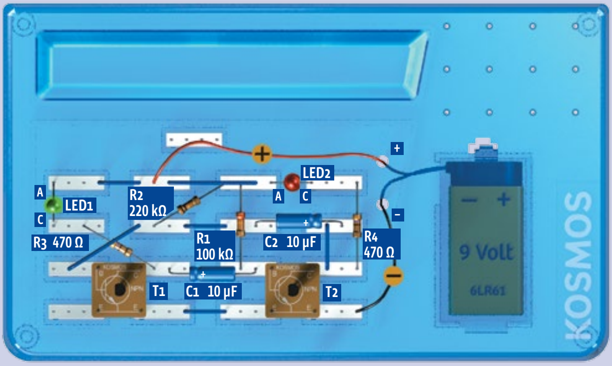


EXPERIMENT 15

Other flash patterns

YOU WILL NEED

→ **your flasher circuit from Experiment 14**
→ ***and additional household items: paper, pencil***



HERE'S HOW

1. Switch the positions of the two capacitors (C1 and C2) in your circuit. Make sure that their poles are turned as shown in the illustration. Does the flash pattern change?

2. You can also try switching the R1 and R2 resistors and then return C1 and C2 back to their original positions.

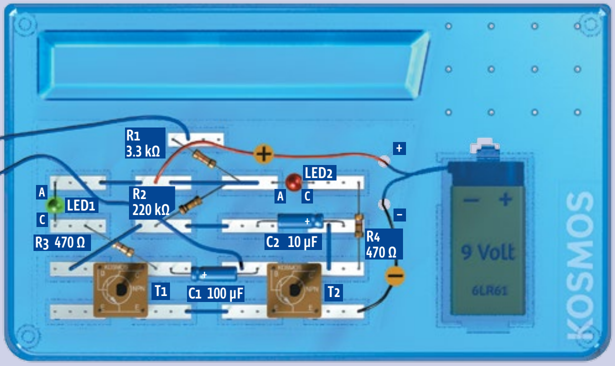
3. Try all the flash combinations you can get by switching the two resistors (R1 and R2) and the two capacitors (C1 and C2). Make a note of which positions produce short or long flash patterns.

→ WHAT'S HAPPENING?

By changing the combinations of R1, R2, C1, and C2, you can get different flash combinations too!

EXPERIMENT 16

Hands as “flash regulators”



YOU WILL NEED

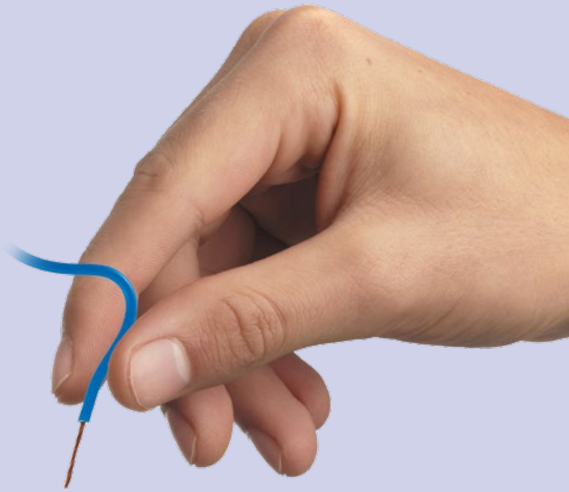
→ your flasher circuit from Experiment 14
→ 2 long wire connectors
→ 1 resistor, 3.3 kΩ

HERE’S HOW

1. Remove the 100-kΩ resistor from the flasher circuit again, and replace it with the 3.3-kΩ resistor.

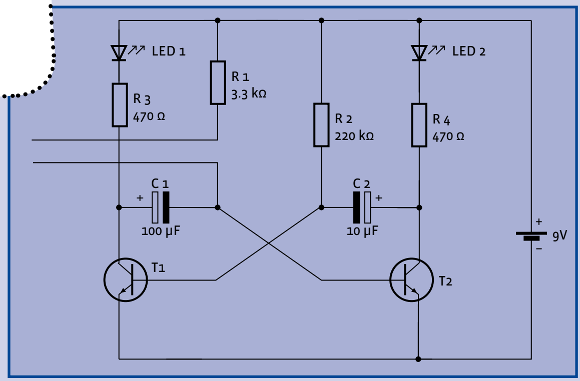
2. Insert the long wires.

3. Take the two bare wire ends between your moistened thumb and forefinger.
   What do you observe?



→ WHAT’S HAPPENING?

Depending on how moist your fingers are, the LEDs will blink faster or slower. So you can regulate their flashing speed by using your skin resistance!

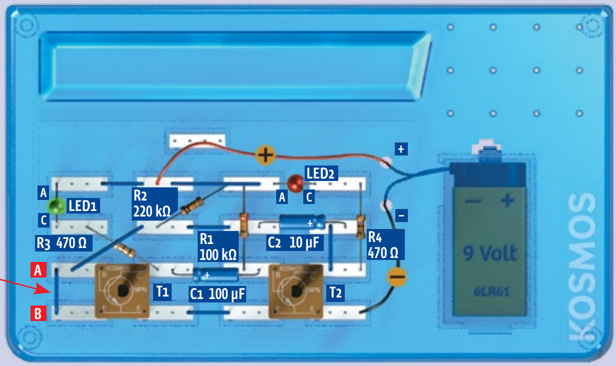


EXPERIMENT 17

Flashing alarm system

YOU WILL NEED

- → your flasher circuit from Experiment 14
- → 1 short wire bridge



HERE'S HOW

1. Insert a small wire bridge into the contact clips at the bottom left. What change do you notice?
2. Remove the wire bridge again.

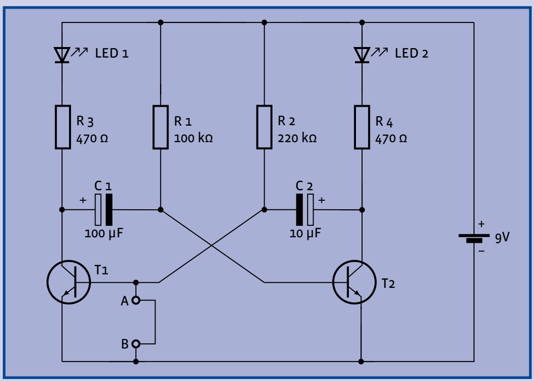
→ WHAT'S HAPPENING?

As soon as you mount the wire bridge on your flasher circuit, the base (B) and emitter (E) terminals of transistor T1 are short-circuited, and the transistor can't work. The flashing immediately stops, and the red LED shines uninterruptedly.

When you pull the wire bridge back out again, the circuit starts to flash: Alarm! That's how easy it is to turn your flasher circuit into an alarm system...

Tip

Instead of the small wire bridge, of course, you could try using a tripwire or a door contact, as you did in the alarm system in Experiment 5.



CHECK IT OUT

What’s that flashing?

→ Can you imagine how a flasher circuit might be used? Think of circuits that switch a light on and off at regular intervals. For example, a blinking light at a pedestrian crosswalk, or at a railroad crossing, or in a shop window display...

And of course, any motor vehicle has a blinker too. A blinker, or turn signal, is a light that is used to signal a change in driving direction to other drivers. So all in all, flasher circuits are very common.

Sensors & Detectors

Dimly glimmering LEDs, electronic wizardry and heat sources — now, aren't you curious to find out about all these things? So let's get started right away with the experiments in this chapter!

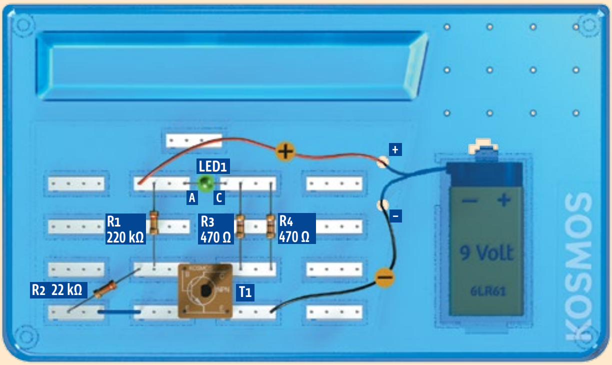
((Kind abbilden???))

EXPERIMENT 18

Battery tester

YOU WILL NEED

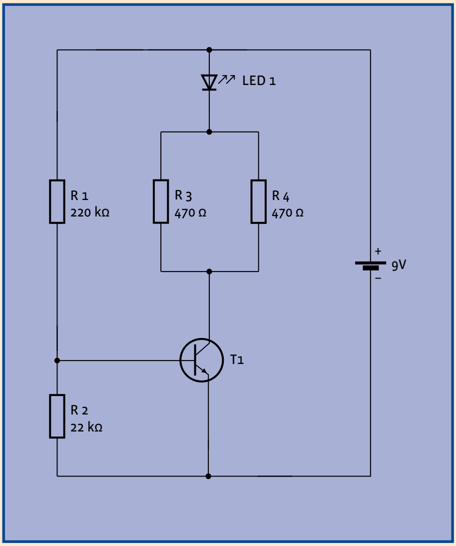
- → 2 resistors, 470 Ω
- → 1 resistor, 22 kΩ
- → 1 resistor, 220 kΩ
- → 1 red LED
- → 1 Transistor module
- → 1 short wire bridge
- → electronics board
- → battery clip
- → *and additional household item: 9-volt square battery*



HERE'S HOW

1. Assemble your battery tester.

2. Connect the battery.
   Does the LED really light up or just glimmer a little?

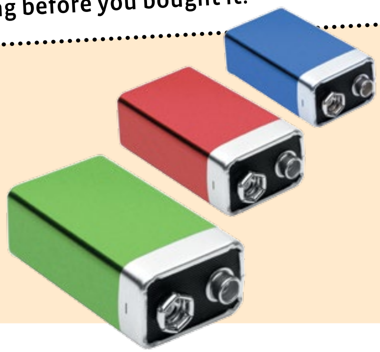


→ WHAT'S HAPPENING?

If the LED shines brightly, you're in luck — it means your battery is still in excellent shape. Or does it only glimmer weakly? If so, take that as a warning. It may mean that the experiments in this chapter won't work with that battery.

Or does the LED not light up at all? If that's the case, check to be sure that none of the components are installed wrong, or whether there's a wire bridge missing. If everything looks good, you can be sure that the cause is a dead battery.

That's how you can tell whether a battery still has enough power. Even a battery fresh from the store might have lost some of its charge just by sitting around too long before you bought it.

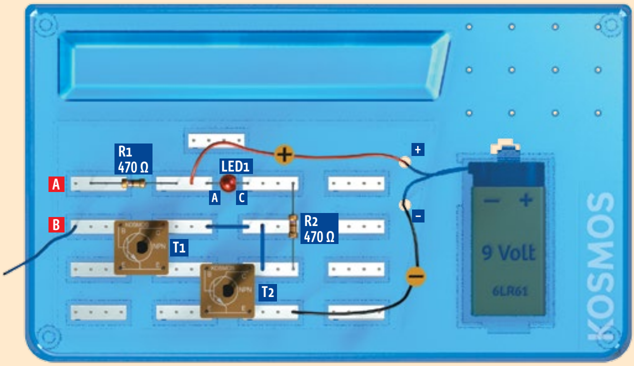


EXPERIMENT 19

Electronic sensors

YOU WILL NEED

- → 2 resistors, 470 Ω
- → 1 red LED
- → 2 transistor modules
- → 2 short wire bridges
- → 1 long wire connector
- → electronics board
- → battery clip
- → *and additional household item: 9-volt square battery*



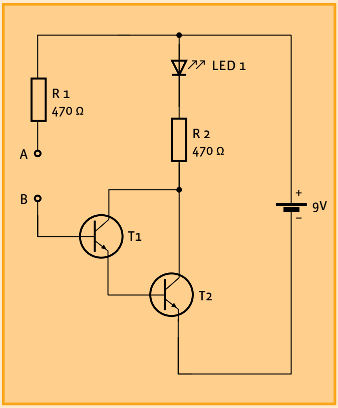
Tip

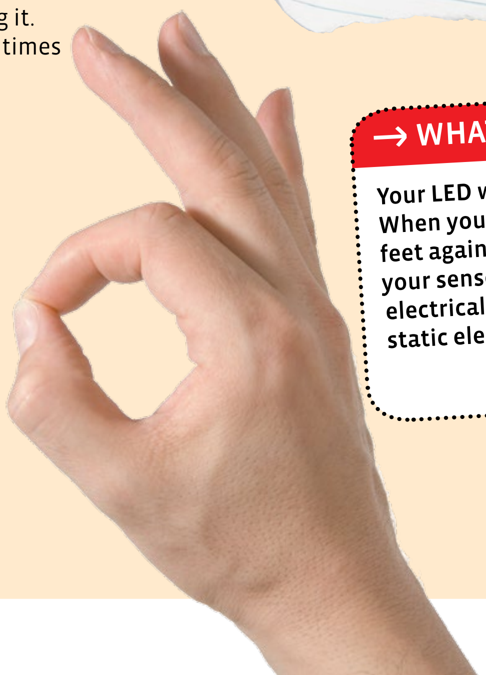
This experiment will work best in a room with a carpet or plastic flooring.

HERE'S HOW

1. Assemble the components as shown in the circuit diagram. At terminal B, insert a long wire vertically, like an antenna.

2. Make an "O" with your thumb and forefinger, and lower this "O" over the antenna without touching it. Shuffle or rub your feet a few times against the floor.
   Do you notice anything?





→ WHAT'S UP?

Your LED will flicker. When you rubbed your feet against the floor, your sensor detected an electrical field created by static electricity.

EXPERIMENT 20

Electronic "magic"

YOU WILL NEED

→ **your electronic sensor from Experiment 19**
→ ***as well as: a few friends***

HERE'S HOW

1. Remove the "antenna." Now it's time to invite a few friends to an electronic magic show.

2. You and your friends should all join hands in a row, with the first person touching contact clip A and the last person with his or her finger on contact clip B.

3. Now, have one of your friends let go of his or her neighbor's hand and then touch the neighbor on the nose or ear.
What do you see?

Tip

By the way: You could also use the green LED for this experiment, of course.

→ WHAT'S HAPPENING?

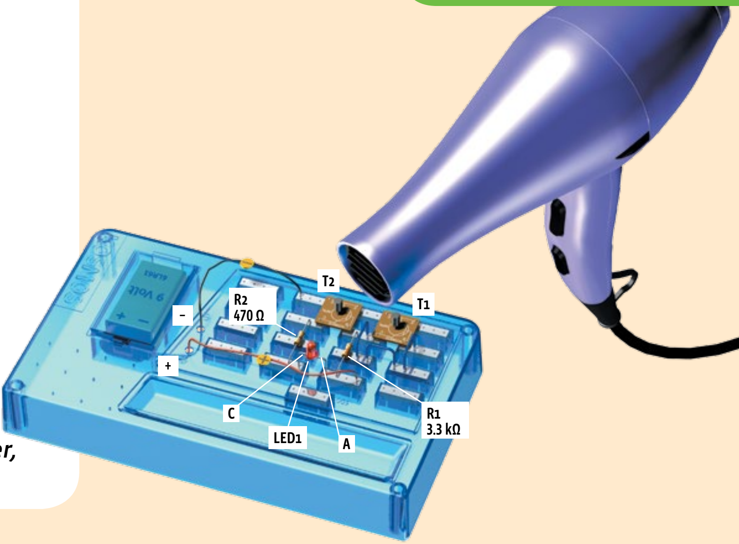
The LED turns on right away. This experiment even works well with more than ten people, because a tiny stream of electric current flows through the bodies of the entire chain of participants, is detected by the electronic sensor, and is then signaled by the LED.

EXPERIMENT 21

Temperature sensor

YOU WILL NEED

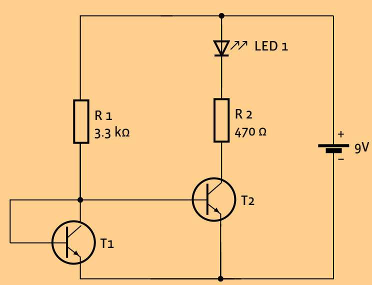
- → 1 resistor, 470 Ω
- → 1 resistor, 3.3 kΩ
- → 1 red LED
- → 2 transistor modules
- → 3 short wire bridges
- → battery clip
- → electronics board
- → *and additional household items: 9-volt square battery, hair dryer, cube of ice*



HERE'S HOW

1. Assemble the circuit, and then heat transistor T1 with the hair dryer, followed by transistor T2.
   How does the LED react when you heat the transistors?

2. Now for the cooling stage: First cool down transistor T1 with the ice cube, then transistor T2.
   How does the LED react now?



→ WHAT'S HAPPENING?

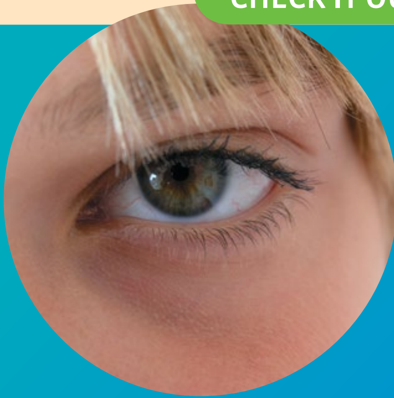
When you heat transistor T1 with the warm air, the LED gradually becomes darker; but when you heat T2, it gets brighter.

When you cool transistor T1 with an ice cube, the LED gets brighter. But as soon as you cool T2, it gets darker.

So you can influence the brightness of the LED by changing the temperatures of the transistors. The temperature differences have to be quite distinct, though — otherwise this trick won't work. That is why you need a hair dryer for heating and a piece of ice for cooling them.

As in the previous experiment, you can use the red LED as well as the green one for this experiment.

CHECK IT OUT



SENSES...

We humans perceive the world through our senses — through our eyes, ears, nose, mouth, and skin. Our senses are very delicate. The human sense of smell, for example, is capable of perceiving even the slightest distinctions.

... AND SENSORS

Electronics can perceive changes in the environment as well — particularly through sensors, also known as detectors. There are detectors for gas, temperature, humidity, sound, light, and a lot of other things. Electronic sensors can also detect things that we cannot perceive at all through our own senses, such as electrical and magnetic fields.

Do you know what a flip-flop is?

A A type of fully automatic electronic switch that is very often used in electronic devices.

B A dance in which you move your shoulders in rhythm to electronic sounds.

C The common name for an old computer diskette.

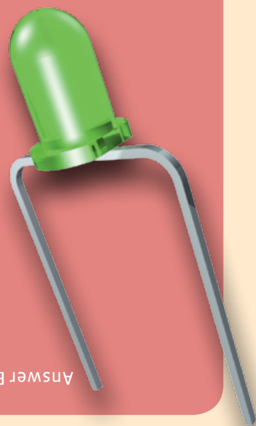
Answer A is correct.

Which side of an LED housing is flat?

A The anode side

B The cathode side

C The electrode side



Answer B is correct.

How many terminals does a transistor have?

A It has one terminal.

B It has two terminals.

C It has three terminals.

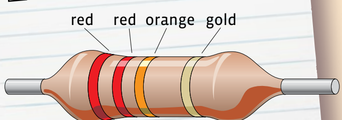
Answer C is right. A transistor has three terminals — the emitter, the base, and the collector.

What kind of resistor is shown here?

A a 470-Ω resistor.

B a 22-kΩ resistor.

C a 220-kΩ resistor.



Answer B is right.

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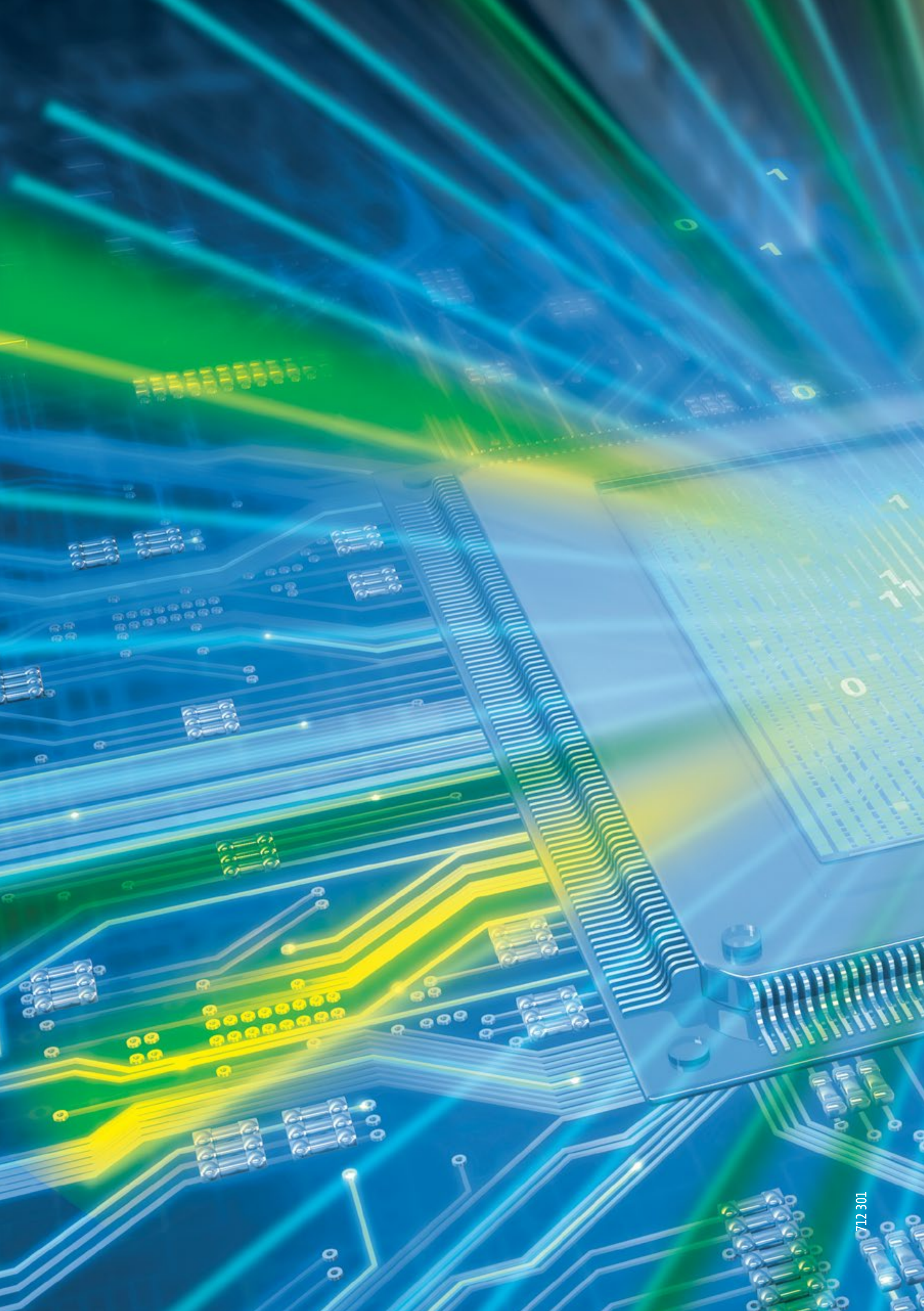

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