

**Supporting Materials for the Use
of the fischertechnik Building Set**

PROFI E-Tec

for Instruction in the Natural Sciences

at the Orientation Level

PREFACE

The summarized supporting materials in this activity booklet for teachers are the result of a project on the subject of "electricity" as part of the natural phenomena instruction for the sixth grade of the general educational school, which is part of the path to a high school diploma, with a natural science profile.

"Natural phenomena" as a subject is part of the instruction in the natural sciences in the Baden-Württemberg schools, which later lead to a high school diploma, in the fifth and sixth grades where the students are to obtain an insight into the impressive world of the natural sciences and technology. The new instructional plan expressly lists the topic of "magnetism and electricity" as part of the competencies and the contents of the educational standards for the sixth grade. The corresponding phenomena are to be examined experimentally in the form of student exercises and within the framework of projects.

For this reason, at the school of the creator of the text, it was important that the instruction be given to groups with a maximum of 20 to 22 students and in the form of blocked hours of 90 minutes each, which means in the afternoon alternately for 14-days and outside of the class group, for example, grade 6a + 6b = 3 groups.

Initially as part of this, parts of the physics device collection were used, which proved to be a problem during the course of time, firstly due to the blocking of these materials for any concurrent practical physics instruction and secondly due to certain shortcomings considering that this equipment is more intended for experimental instruction for higher grades.

Thus, the idea arose that components could be used from commercially available experimental kits. In this case, fischertechnik was chosen because with the assortment available other topics, for example, from the areas of kinetics, mechanics or statics could be experimentally examined and when making illustrative models can be connected with those from the area of the science of electricity. In particular, the possibility of illustrating and acquiring in-depth understanding of physical facts through the construction of functional models is in accordance with the intention of the subject of natural phenomena.

Supporting Materials

The building set, which was developed by the fischer plants in 2003, "PROFI E-Tec," allows children and young people to obtain a clearer understanding of the use of electricity in various forms by means of several models.

The following pages provide information, which comes from initial experience with the use of this building set, for teachers and students and this can also be transferred to other school types and countries.

ORGANIZATION OF THE INSTRUCTION

Methodical and Subject-specific Didactical Information

Some of the most important skills in the instruction on natural science experiments are the proper and careful use of devices and aids. Mutual respect and cooperation are practiced in small groups and in this way the social skills of the students are strengthened. The exchange of experience between groups promotes communications in a way that this is not perceived to be a disturbance factor. As part of this, students can also help others in the handling of problems concerning understanding and give the teachers positive and negative feedback about possible changes.

For the instructional unit, which is to be completed with the help of the "PROFI E-tec" building set, five to six two-hour periods are to be planned for the second quarter of the school year. This unit is preceded by the treatment of the term energy and energy conversion in order to better understand the importance of electricity and this can also be done with the help of fischertechnik. See above.

Following the treatment of electrical power and its areas of application, it is useful to study the topic of renewable energies so as to close the circle to a certain degree by examining the alternatives for the better use of original and natural forms of energy through modern technologies.

Experimental study is also possible for this subject area using the fischertechnik building set, "PROFI Eco-Power," which mainly contains components that are also found in the "PROFI E-Tec" in addition to special components.

This addition and conclusion also assure that the topics of "energy" and "electricity" are examined not only from a purely physical and technical viewpoint, but also from an aspect that applies to several subject areas. At the orientation level, many of these topics will be discussed in the future in geography and biology instruction after the children in primary school have obtained initial insights through the subject combination of "people, nature and culture," according to the instructional plan of the state of Baden-Württemberg.

In order to introduce the basic terms about the function of simple electrical circuits and switching circuits (construction instructions p. 5–13), initially work is started on the same front. Even at this point, the differences in perceptive faculties, technical understanding and prior knowledge of the students are noticeable so that it is useful to give them the choice in the following hours as to what models they want to independently experiment with for other circuit technologies. Using the E-Tec module, the basic terms for electronics and their importance for our daily life can also be examined.

Practical Instructional and Technical Procedural Information

In order to achieve these methodical and subject-specific didactical goals, the strict observance of the order and the instructions is necessary!

Therefore, the consecutive numbers of the building sets are entered in a list along with the names of the students using the particular kit. An additional list can be used to record reports about missing or damaged parts. This gives the teacher the opportunity to monitor the completeness and the following of the instructions and thus an evaluation of the students. The teacher can make the list according to the requirements such as the group number, group size and number of available building sets. See the **sample** in the appendix.

The students receive information about the use of the building sets for this purpose.



Master copy 1

For the use of the building set, "PROFI E-Tec," it is recommended that a double set of 1 NC batteries 9V and a charging device be purchased so that discharged batteries can be replaced with charged batteries. Frequently occurring errors, which cannot be completely avoided, during the formation of circuits can lead to short circuits and thus to the discharging of the batteries. For non-rechargeable batteries, this would lead to high consumption and thus higher costs and to environmental impact when disposing of these batteries!

Supporting Materials

This type of power supply permits the instruction to be given without being limited to a room, which is specifically meant for the natural sciences, and can thus be given in a classroom, which also provides greater flexibility when making the hourly schedule.

At the start of each two-hour period, short written tests are given to examine what was learned and the results of this are then part of an overall grade. They are so structured that a maximum time of 10 minutes is sufficient for completion by the students and correcting the tests can be done very fast as well. This assures that the teacher can quickly get an overall impression about the success or lack of success and this allows the teacher the opportunity to make additions and corrections during the further course of the instruction.

This type of testing is intended to motivate the students to read and examine the construction instructions and the associated information in the activity booklet more intensively. Experiences shows that many children tend to just try things out and to give little attention to the instructions and thus cannot solve the task given to them!

The recording of the knowledge from the construction of the models and entering of the results are done using the **worksheets** (master copies 2–7) for the students.

Instructions for the Use of the Building set

1. A unit in the building set consists of three stackable boxes with a cover, which is used as a working surface.
2. The boxes are divided into compartments of various sizes and show a overview of the contents of the compartment on the floor of the compartment.
3. Each workgroup, which consists of two students, always uses the same boxes, which have numbers on them. These and the names of the users are entered in a list.
4. It is not permitted to change the assignment of the boxes and to exchange parts between different kits.
5. When building a circuit or a model, only take the required parts from the compartments. This information is given for the individual work steps in the instruction manual.
6. When a part is no longer needed, then it is to be put back into the correct compartment immediately.
7. You are only to do what the teacher has assigned as a work task and what stands in the work instructions!
8. Get into the habit of never pulling on cables because this can uncover parts, which are carrying electricity.

For example, this can be life endangering in the case of household appliances and damaged cables can cause a fire!

Name	Class	Sheet No.

ELECTRICAL POWER

With the help of this worksheet, you are to first obtain some information about electrical power so that you can better understand the way it works when you are working with the building set. For the various parts, which you use for this, you will find information in the activity booklet. So read the corresponding sections in the booklet very carefully!

You are certainly familiar with the terms power and current in other connections.

For example, you have heard or read that a river has a strong current or a basketball player has lots of power in his legs and can jump high.

Can you name other examples?

Can you call every movement power or current?

What requirements must be fulfilled so that you can use these terms? Add to the following sentence!

When there is a current in a river then the water _____

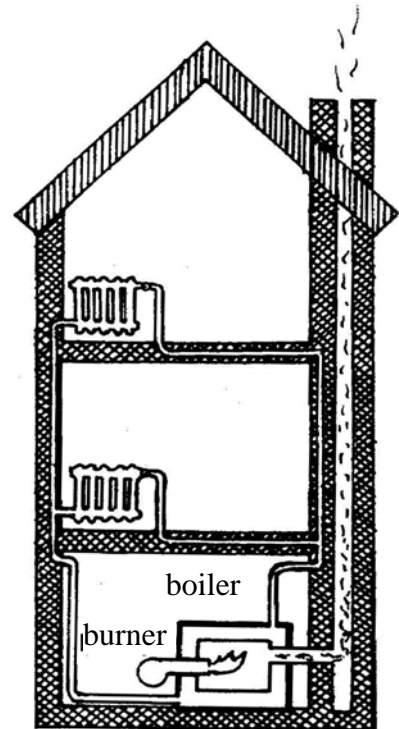
For electrical power very small particles move that are called electrons in a conductive material. Just as water in a big river is a part of a big circulation system—the ocean, evaporation, cloud formation, transport to land, condensation, rain, surface runoff and/or seepage into the ground, springs and flowing water and back to the ocean—which is kept in motion by the sun as a kind of pump, so move the electrons from a source of power in an electrical circuit and then back again. Just like the current of the water and the power in this current can be used by a water wheel to drive various machines, the energy of electrical power can be used for various purposes by transforming this into other forms of energy.

Name	Class	Sheet No.

A SIMPLE CIRCUIT

The sketch at the right shows you another comparison.

In a central heating system a burner heats water in a boiler. This then flows, which is supported by a pump in most cases, through pipes to the radiators in the rooms. By opening or closing the valves on the radiators, the supply of water and thus the amount of heat can be controlled. The radiators are formed so that they can easily transmit heat to their surroundings. This means that the the water in the radiators is cooled and then flows back to the boiler to be heated there again.



In the sketch in the heating circuit color the pipes and the parts of the boiler and the radiators, which contain hot water, red and the pipes with cooled water blue. When you do this, remember that hot water rises and cold water sinks.

Now you can see the principle of the electrical circuit in comparison to this circulation when you carefully read the information and reference to the drawing in the form of a circuit diagram and complete the tasks, which are contained in the activity booklet on page 2 section 2.2, The Simple Circuit.

Add the missing terms in the following table, which means add those terms that correspond to the term listed in the other column.

Heating Circuit	Simple Circuit
Boiler	
	Supply cables
Radiators	

Name	Class	Sheet No.

Electrical Circuits

Your Task

First, build on your working surface as described on page 2 of the activity booklet a simple circuit. Then remove one connecting line between the power source and the light bulb and install a **push button**, which is in the building set. Connect the free line of the power source with the jack 1 of the button and with another line from the building set you can connect the light bulb with jack 2.

So that you do not have to write in the activity booklet because you know that this booklet is used by other groups and you don't want to reveal your solutions, you can enter the results here.

Connection 1 and 2	Light bulb		Connection 1 and 3	Light bulb
Button is not pressed.			Button is not pressed.	
Button is pressed.			Button is pressed.	

When you build the flashlight and the light for the refrigerator, you can try out the practical use of closing switches and contact breakers and closers and openers.

With this knowledge, you can now complete these sentences:

With a closing switch, a circuit is _____

With a contact breaker, a circuit is _____

The push buttons from fischertechnik are _____

Name	Class	Sheet No.

CONDUCTORS AND NONCONDUCTORS

You already know that electrical power is concerned with the movements of electrons through a material. To get an answer to the question about what materials conduct electricity (allow it to pass) and what ones don't, you can build a simple device to test this.

Your Task

Using your continuity tester determine what materials are conductors and which ones are nonconductors. Select the corresponding materials yourself.

Material	C	N	Material	C	N	Material	C	N

Name	Class	Sheet No.
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SERIES CONNECTION AND PARALLEL CONNECTION

Here, this deals with the use of several lights or other power consumers and several switches.

Your Task

First build a circuit in the sense of a simple circuit, that is with only one light. Then connect another light as shown on page 10 of the construction instructions. Then, compare the brightness of the lights!

Comparison with only one light	Brighter	Same brightness	Dimmer
Parallel connection			
Series connection			

Now, use one light and two switches (push buttons) and arrange them on your working surface as shown on page 11 of the construction instructions. Then, evaluate your observations using the following table.

Does the light light up?	Parallel connection	Series connection
When no button is pressed.		
When the first button is pressed.		
When the second button is pressed.		
When both buttons are pressed.		

Think about why the other electrical Christmas tree lights go out when only one of the lights is removed from the socket.

Answer: _____

At home, look to see where you find **two-way switches**. Count the maximum number that are there for the switching on or off of a light bulb.

Most two-way switches in our apartment or our house are located _____.

There are _____.

Name	Class	Sheet No.

THE MOTOR

Now, we are going to get down to business!
But it will also be more complicated!

Now, you must follow the construction instructions very exactly so that the parts of your models fit together and that they also work.

For the next experiments, we will use a motor as an additional component that uses power and transforms this energy. For an elevator, we can let the motor run in different directions with two switches. When both push buttons are arranged so that can be operated alternately by a lever between them then the effect is the same as if you would exchange both supply cables to the motor. Since this about the same as reversing the polarity, a switch that works in this way is called a pole-reversing switch.

Your Task

Think about devices that could use such switches so that the motor can rotate to the left or right.

Examples:

a) _____ b) _____ c) _____

Name	Class	Sheet No.
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STOP LIGHT CONTROL

The next models use a motor to turn on and turn off lights alternately. This means that the lights and the motor represent parts of different circuits and the supply cables from the source of power to the power consumers must branch. Therefore, you must pay very good attention to the circuit diagrams.

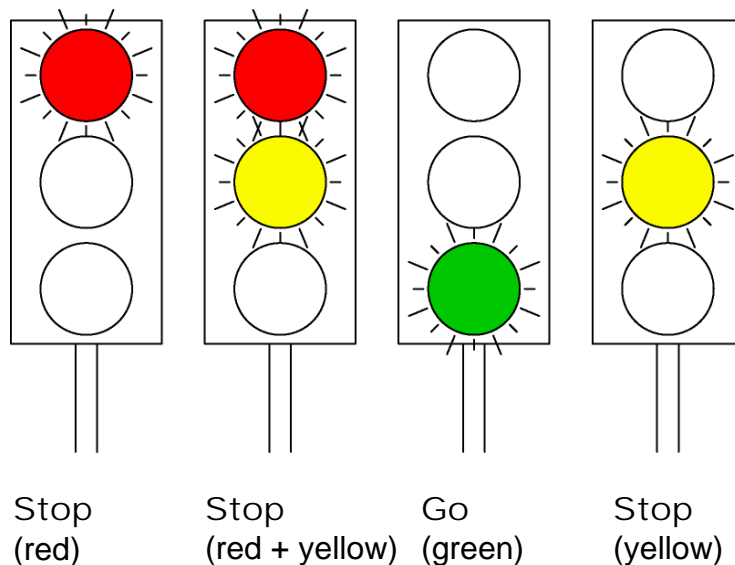
Your Task

Look at the circuit diagram on page 27 very closely and follow the path of the electrical power through the lights and the motor.

How many circuits are connected with each other?

There are ___ circuits, namely one for each _____

If you succeeded with the control of the stop light for the red-green change, then think about how you would build a stop light, which also switches to a yellow phase.



Name	Class	Sheet No.
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MAGNETIC SENSOR + PHOTOTRANSISTOR

Up to now, you have learned how to operate switches to control various functions, such as turning lights on and off or to make a motor run forwards and backwards. The control using switching drums showed you how it is easier compared to a purely manually operated switch. If you think about how such an electromechanical control would have to be built for the many blinking lights on a neon billboard, then it becomes clear that another technology is necessary for this. Earlier, you learned that for mechanisms for the transmission of force, these are only of limited use because the energy losses due to friction are very high.

Just as the capability to conduct electrical power over greater distances represented decisive technical progress, the development of **electronics** also made things tremendously easier in many respects. Not only does this save a lot of energy because there are no losses due to friction, but this also saves a lot of material because here many circuits can be combined in a very small space. In the final analysis, this also conserves our nature!

The PROFI E-Tec building set also contains such a component: the **E-Tec module**.

This will be used for the next models together with additional switching capabilities namely a magnetic sensor and a phototransistor.

Your Task

Learn about these components in the activity booklet and enter their function here.

The magnetic sensor (reed contact) _____.

The phototransistor _____.

These examples of applications clearly show how our life has been made much easier and safer in a decisive way.

Both sensors protect us against _____

Name	Class	Sheet No.
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SHORT TEST 1

Enter an X or enter the right term!

1. When electrical power flows in a copper wire then many tiny particles move in a certain direction in this wire. These are called

Atoms	<input type="checkbox"/>
Molecules	<input type="checkbox"/>
Electrons	<input type="checkbox"/>
Conductors	<input type="checkbox"/>

2. Electrical power can be dangerous.

- 2.1. The power for our household appliances that we get from the electrical socket with 220-230 volts is, however, not dangerous.

This statement is

True	<input type="checkbox"/>
False	<input type="checkbox"/>

- 2.2. A swallow, which comes into contact with a conducting wire, which is carrying 1000 volts of voltage, will be killed by this.

This statement is

True	<input type="checkbox"/>
False	<input type="checkbox"/>

3. A circuit consists of at least three components.

1. _____ 2. _____ 3. _____

Name	Class	Sheet No.

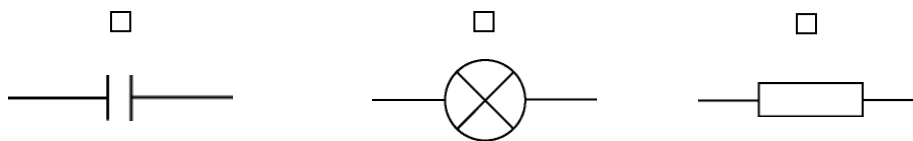
SHORT TEST 2

Enter an X or enter the right term!

1. So that the small light in our flashlight, which we built, lights up, electrical power must flow through it.
The power source for this supplies power with a certain voltage.
In our case this is

1 V	
9 V	
110 V	
220 V	

The light is shown in a circuit diagram with a certain symbol.
Which of the symbols shown here is correct?



2. To allow the electrical power to flow through the light or to interrupt this flow, you use a switch.
Think about the function of the switch in a flashlight and of a switch in a refrigerator when you open the door of the refrigerator the light goes on.

The switch in a flashlight _____ the circuit.

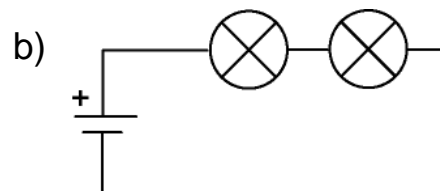
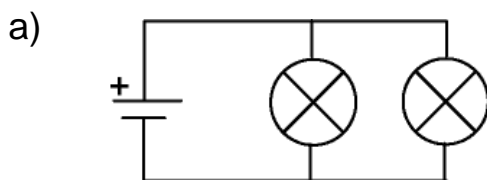
The switch in a refrigerator _____ the circuit.

Name	Class	Sheet No.

SHORT TEST 3

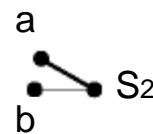
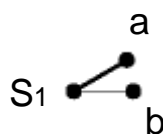
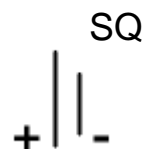
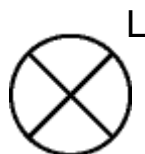
Enter an X or enter the right term or complete the circuit diagram.

1. Here, you see two circuit diagrams each consisting of a power source and two lights. However, they differ with respect to the arrangement of the lights in the circuit. Name both circuits with the right terms and enter an X to show how the lights are illuminated compared to one light in the circuit.



Brighter	Same brightness	Dimmer	Brighter	Same brightness	Dimmer
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2. Two children are sleeping in a room. However, there is only one light for reading in the room and this gives enough light for both. There is a switch for the light on each bed. Connect the two switches and the light bulb with the power source so that the light is illuminated when one of the two switches is operated.



Name	Class	Sheet No.
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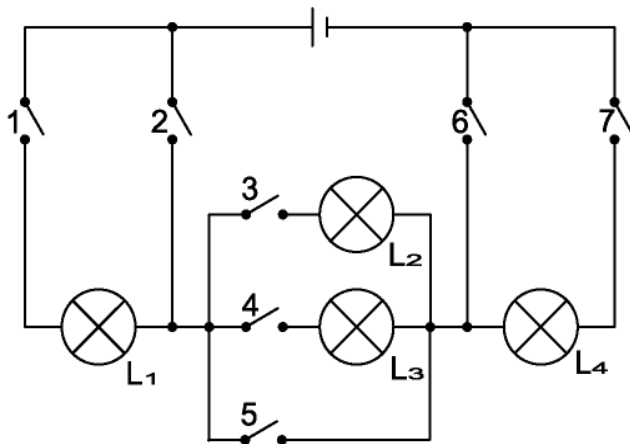
SHORT TEST 4

In the last hour, you experimented with various switches. When you built the light for the refrigerator, the elevator, the blinking light, the tower with the blinking warning light, the stop light control, the alarm system or the handdryer, this was always concerned with the turning on or the turning off of lights or a motor with various switches such as a push button, a magnetic switch or a light barrier.

Therefore, for the next experiments you should always be sure as to how circuits work and how you read or draw a circuit diagram. Remember that when working with higher voltages and currents, electrical power can even be life endangering! So, make a habit of being very careful even when using our models from the building set.

To test your present knowledge, carefully examine the following circuit diagram.

Which switches must be closed so that the following lights are illuminated? Write the numbers in column 2.



The light to be illuminated is:	Closed switches
Only light 1	
Only light 2	
Only light 3	
Only light 4	
Lights 1 and 2	
Lights 2 and 3	
All lights	

Which switches may not be closed at the same time because otherwise there will be a short circuit?

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Name	Class	Sheet No.

SHORT TEST 5

Now, you have learned through the construction of various models, how electrical power can be used and how we can make our lives easier through such use.

What determines how fast a light blinks? Place an X by the right statement.

Direction of rotation of the motor Rotational speed
 Number of switch wafers

A magnetic sensor may be used instead of a push button to turn something on or off if you put a magnetic object in its vicinity. A phototransistor reacts accordingly when the light beam is interrupted.

What function do both of these components have for the following models? Enter in the table if they act as a closing switch or a contact breaker.

	Magnetic Sensor	Phototransistor
Alarm system		-----
Handdryer	-----	
Punch press		
Garage door		-----
Parking garage bar barrier		
Building block dispenser		

For all of these models, you also built in the E-Tec module. It processes electronic data and commands like a small computer.

Its most important part is called: _____

Dip switch Microprocessor
 Monitor Keyboard

Name	Class	Sheet No.

School

Natural Phenomena Grade 6

List of deficiencies for fischertechnik building set, PROFI E-Tec

Two-hour period		1	2	3	4	5	6
Kit No.							
1	A						
	B						
2	A						
	B						
3	A						
	B						
4	A						
	B						
5	A						
	B						
6	A						
	B						
7	A						
	B						
8	A						
	B						
9	A						
	B						
10	A						
	B						
11	A						
	B						
12	A						
	B						

Name	Class	Sheet No.
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Assignment of the Building Sets

School.....
Natural Phenomena Grade 6

Assignment of building sets fischertechnik PROFI E-Tec

No.	Group 1		Group 2		Group 3	
	Name	Name	Name	Name	Name	Name
01						
02						
03						
04						
05						
06						
07						
08						
09						
10						
11						
12						

Name	Class	Sheet No.
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