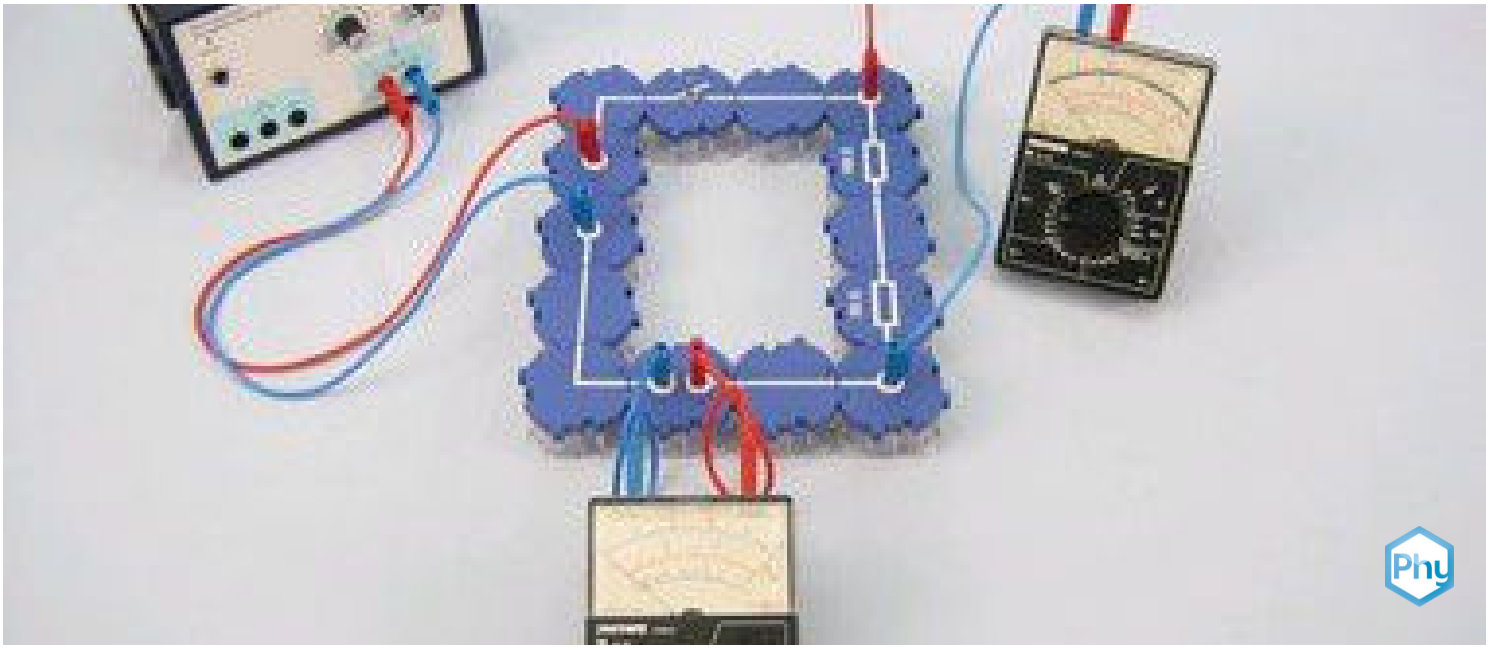
Current and resistance in a series connection



Physics | Electricity & Magnetism | Simple circuits, resistors & capacitors

Difficulty level	Group size	Preparation time	Execution time
medium	2	10 minutes	10 minutes

This content can also be found online at:

http://localhost:1337/c/6307ccf81c1bff00033e1a8c

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Teacher information

Application

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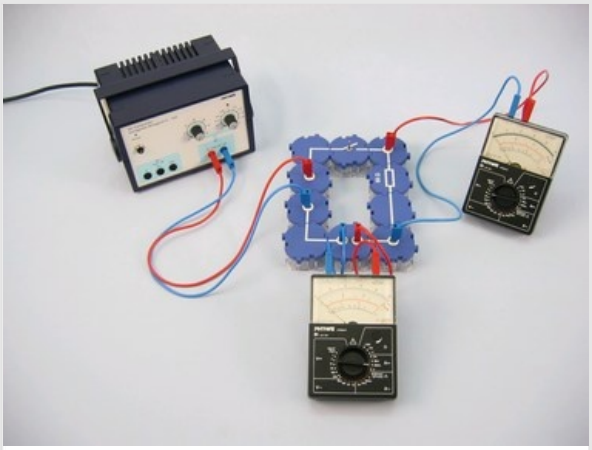

Experimental setup

Series circuits are used in most electrical appliances, but they are particularly clear in fairy lights. In the past, fairy lights were built in series, but the disadvantage was that if one bulb failed, the entire fairy light went out, so they are rarely built with a series circuit nowadays. Another example used today is alarm systems.

The current strength is the same at every point in the circuit $I_G = I_1 = I_2$.

The voltage and thus also the resistance result from the addition of the partial voltages or resistances.

$U_G = U_1 + U_2$ and $R_G = R_1 + R_2$

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Other teacher information (1/3)

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Prior knowledge

Students should be able to construct a simple circuit and be aware of what voltage and current are. Additionally, the principle of resistance should be understood and the formula $R = U/I$ be known.

Learning objective

Using the measured values they have obtained, the students are to explain the relationship between the partial current strengths I_i of a series connection and the total current I_G. In addition, they should learn the relationship between partial resistances R_i and total resistance R_G in a series connection.

Other teacher information (2/3)

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Task

Investigate the relationship between the total amperage I_g and the partial currents I_i and between the total resistance R_g and the partial resistances R_i consisting in a series connection.

Principle

In the first part of the experiment, incandescent lamps are added one after the other in a series circuit and qualitative observations are made on the brightness.

In the second part of the experiment, the total current intensity is first measured for two resistors of different sizes, which are then combined. Finally, the partial current strengths in front of, behind and between the two resistors are measured.

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Other teacher information (3/3)

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Notes

The first part of the experiment is intended as a preliminary experiment to obtain a problem definition and is intended to introduce the laws of series connection in a qualitative manner.

The subsequent parts of the experiment are intended to record these regularities quantitatively. In the second part of the experiment R_1 and R_2 are not immediately connected in series, but both resistance values are first determined experimentally. The advantage is that it is possible to proceed analogous to the first part of the experiment and that a comparison of the measured values for R_1 and R_2 with the value for R_G is possible.

In the second part of the experiment, the applied voltage must be kept constant. Before each measurement of the current, the students have to check the voltage and set it to 10V.

Safety instructions

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The general instructions for safe experimentation in science lessons apply to this experiment.

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Student information

Motivation

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Light chain - light bulbs in series connection

Series circuits are installed in most electrical devices, but their characteristics are particularly illustrative in fairy lights. In the past, the light bulbs were connected in series. However, since the failure of one bulb directly extinguishes the entire light chain, they are no longer usually installed in series.

Another example is alarm systems, where the various switching contacts are connected in series and form an "alarm loop". As soon as a contact is interrupted, the alarm system is triggered.

In this experiment, you will learn exactly how the current and the resistance behave in a series circuit.

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Equipment

Position	Material	Item No.	Quantity
1	Straight connector module, SB	05601-01	4
2	Angled connector module, SB	05601-02	4
3	Interrupted connector module with sockets, SB	05601-04	1
4	Junction module, SB	05601-10	2
5	Angled connector module with socket, SB	05601-12	2
6	On-off switch module, SB	05602-01	1
7	Socket module for incandescent lamp E10, SB	05604-00	2
8	Resistor module 50 Ohm, SB	05612-50	1
9	Resistor module 100 Ohm, SB	05613-10	1
10	Connecting cord, 32 A, 500 mm, red	07361-01	2
11	Connecting cord, 32 A, 500 mm, blue	07361-04	2
12	Filament lamps 4V/0.04A, E10, 10	06154-03	1
13	PHYWE Analog multimeter, 600V AC/DC, 10A AC/DC, 2 MΩ, overload protection	07021-11	2
14	PHYWE Power supply, 230 V, DC: 0...12 V, 2 A / AC: 6 V, 12 V, 5 A	13506-93	1
15	Connecting cord, 32 A, 250 mm, red	07360-01	1
16	Connecting cord, 32 A, 250 mm, blue	07360-04	1

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Set-up

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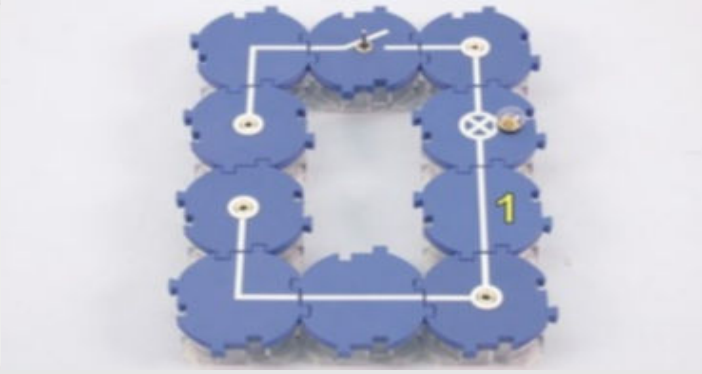
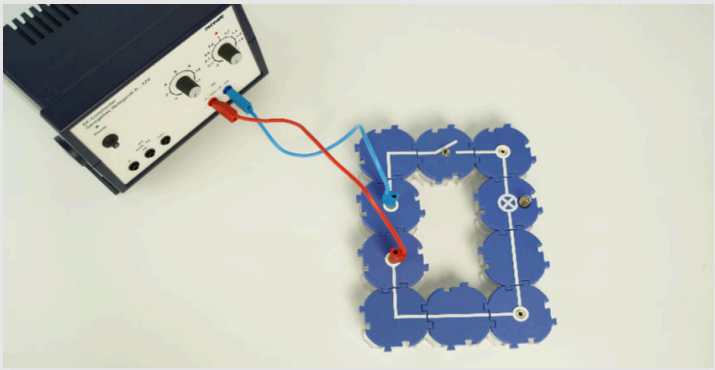
First set up the circuit as shown in the illustrations below.

The switch is initially open. Insert the 4 V bulb into the lamp socket.





Procedure (1/4)

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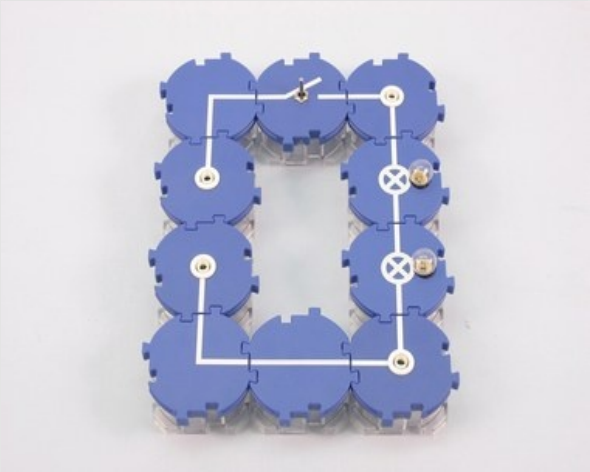
- Set DC voltage to 4V at the power supply unit and set the current limiter to 2A (right stop). Close the switch.
- Observe the brightness of the bulb.
- Instead of the line component 1, install the second bulb in the circuit as shown in the illustration on the right.
- Observe the brightness of the bulbs and compare it with the previous brightness of the individual bulb.
- Think about how the observations can be justified.



Series connection with two light bulbs

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Procedure (2/4)

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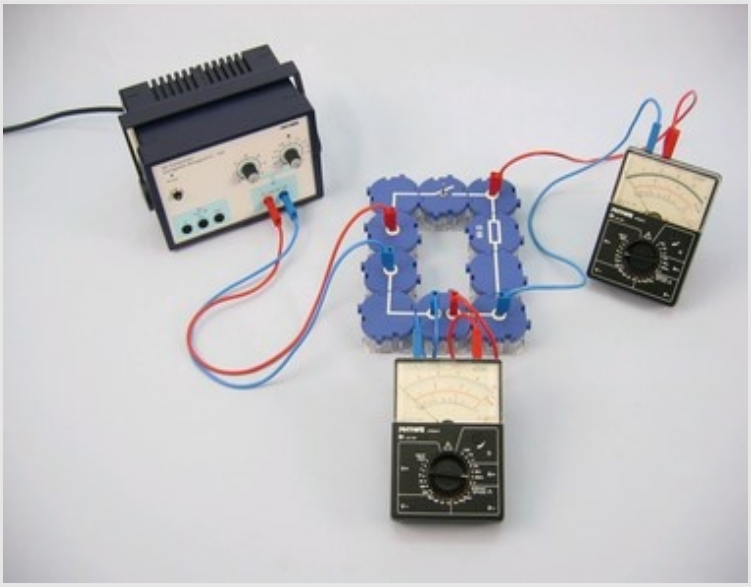

- Now build the circuit according to the illustration opposite with the resistor $R_1 = 50\,\Omega$ on.
- Select the measuring ranges 10 V- and 300 mA.
- Set a DC voltage of 10 V, measure the resulting current and record it in the report.

Procedure (3/4)

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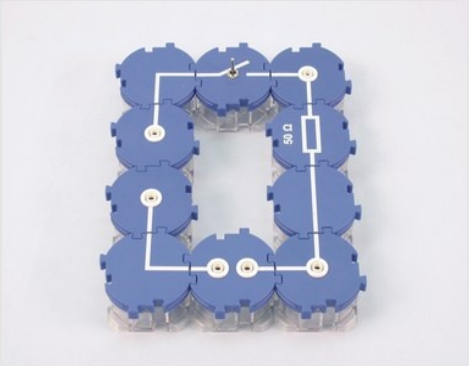
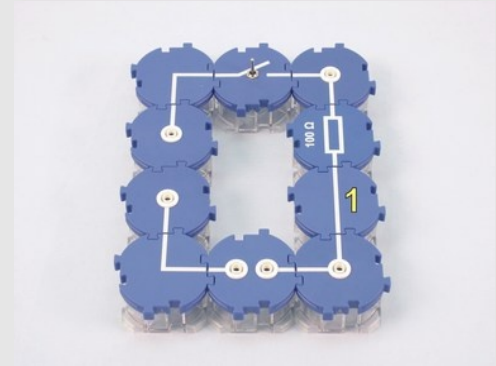
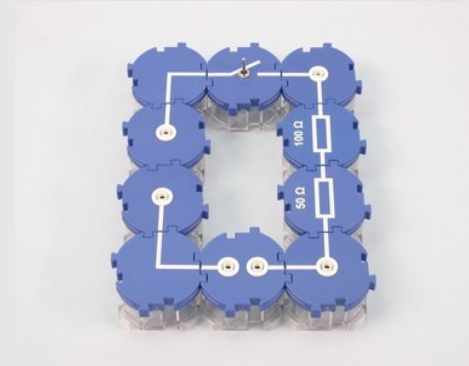
Replace the resistor with the resistor $R_2 = 100\,\Omega$(Fig. in the middle). Equalise the voltage to 10 V and measure the current. Replace the line component 1 with the resistor R_1 (Fig. right), adjust the voltage to 10 V again and measure the current. Record both measurements in the report.







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Procedure (4/4)

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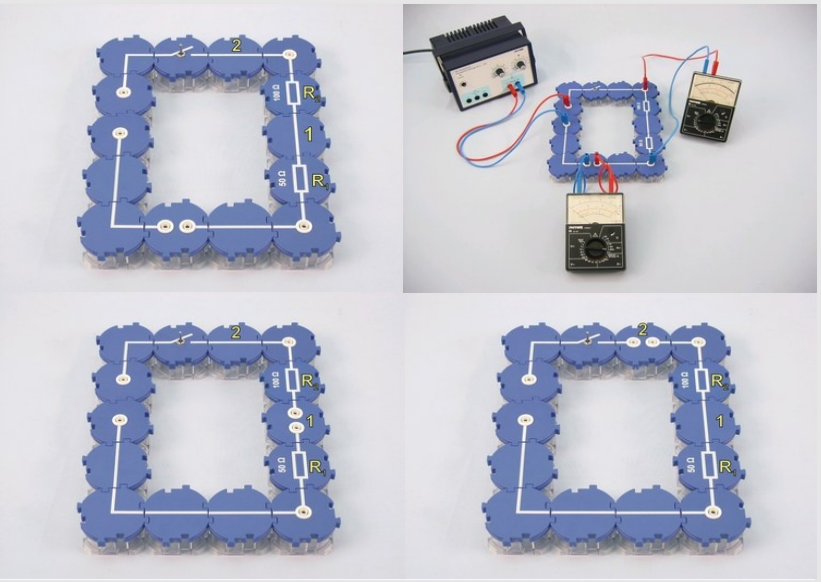
- Change the series connection according to the two figures above.
- Set the DC voltage to 10 V.
- Measure the current before R_1, between R_1 and R_2 and behind R_2 and note down the values. To do this, after the first measurement, switch the ammeter into the circuit where the power modules 1 or 2 were initially (Fig. below left, below right).
- Record your readings in the report and switch off the power supply.



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Report

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Task 1

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After the second bulb has been added,...

- ...no light bulb lights up.
- ...both bulbs shine equally brightly.
- ...the first bulb shines brighter than the second.
- ...the second light bulb shines brighter than the first.

After the second bulb has been added,...

- ...the brightness has remained the same.
- ...the brightness of the first light bulb has increased.
- ...the first light bulb no longer lights up.
- ...the brightness of the first bulb has decreased.

Task 1

PHYWE

After the second bulb has been added,...

- ...no light bulb lights up.
- ...both bulbs shine equally brightly.
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After the second bulb has been added,...

- ...the brightness has remained the same.
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Task 2

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Enter the measured values for the second part of the experiment in the table.

Then calculate the values for R from the measured voltages and the resulting currents and enter them in the third column.

Resistors	$U\,[V]$	$I\,[A]$	$R\,[\Omega]$
$R_1 = 50\,\Omega$			
$R_2 = 100\,\Omega$			
R_1 & R_2			

What is the correlation, taking into account possible measurement errors, between the resistances R_1, R_2 and R_G (R_1 and R_2 in row) in the right-hand column?

- $R_G = R_1 - R_2$
- $R_G = R_1 + R_2$
- $R_G = R_1 \cdot R_2$

Task 3

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Enter the measured currents for the different measuring positions X relative to the resistors R_1 and R_2 into the table.

Position (X)	$I\,[A]$
$X - R_1 - R_2$	
$R_1 - X - R_2$	
$R_1 - R_2 - X$	

What formula can be derived from the measurements for the current in a series circuit? Think about why this is so.

- $I_G = I_1 + I_2$
- $I_G = I_1 - I_2$
- $I_G = I_1 = I_2$
- $I_G = I_1 \cdot I_2$

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