Low-Cost Experiments in STEM Education

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Building El. Circuits Using Copper Tape, Magnets and 3D Printing

In our demonstrations, we use clearly visible and transparent el. circuits. These circuits incorporate low-cost and high-tech components ranging from copper tape and graphite pencils to components housed in 3D-printed magnetic boxes. These boxes can be interconnected via magnetic wires.

Started as simple…

Pencil circuits consist of conductive curves drawn with a pencil. The graphite used in pencils is conductive, similar to the markings they create. Because the graphite layer is very thin, the resistance is high.

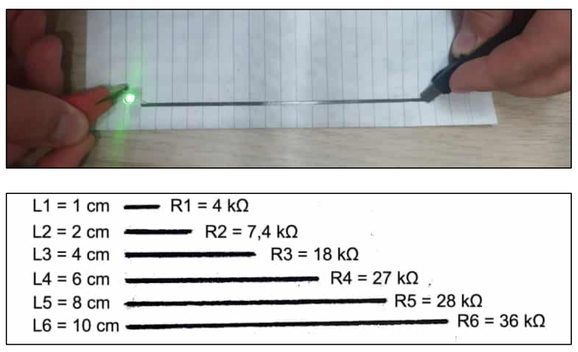


Fig. 1 Graphite curve as a conductive path

Conductive paths made from copper tape are used instead of traditional wires. The tape is flat, sticky, and offers good conductivity. This allows students to creatively combine physics and art.

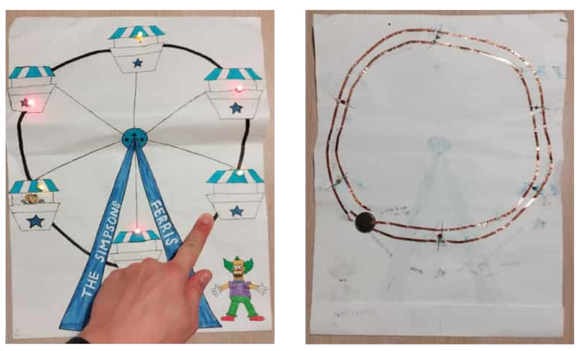


Fig. 2 Copper tape as a conductive path

Multivibrator made from copper tape is a simple circuit that shows the way of electric current. By fixing small magnets under the tape, it is possible to interchange components easily. Changes in the parameters of capacitors and resistors affect the frequency of an LED's blinking.

Fig. 3 Multivibrator

Electromagnetic induction can be simply demonstrated using a circuit composed of three parts, employing copper tape instead of traditional wires and coils.

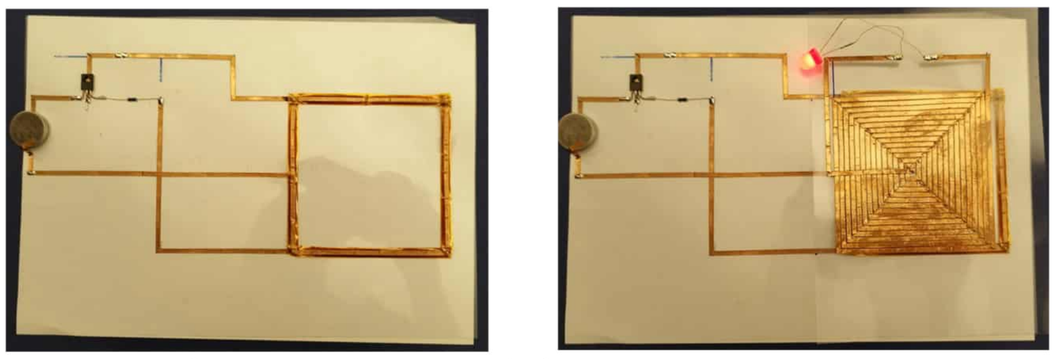


Fig. 4 Circuit for elmg. induction made from copper tape

Speaker is using a coil made from tape, which is connected to a Bluetooth device that includes a receiver and an amplifier. When a phone is connected and a magnet is placed under the coil, the speaker plays music.

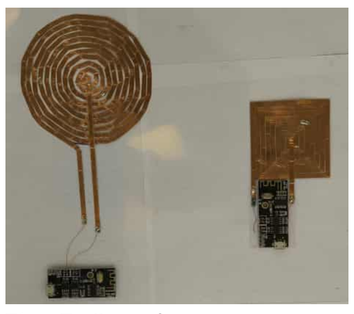


Fig. 5 Speaker

Capacitor is a simple component that consists of two layers of copper tape separated by a dielectric medium, which in our case is a decorative collar used for the cake sides.

Fig. 6 Capacitor

…finished as high-tech (but still simple)

We use 3D printer to make our custom demonstrational kit to use in primary-school teaching of electric circuits. All parts of the kit are magnetic so you can use them on the black/whiteboard. The feature we took from copper tape is the „see-inside principle“.

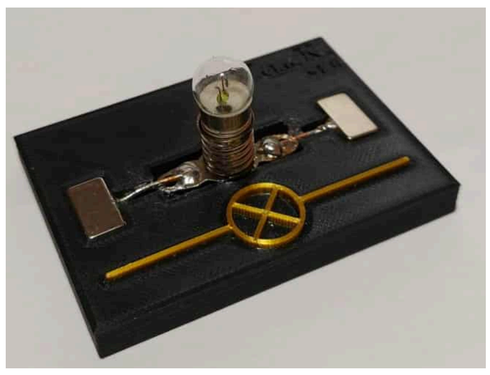


Fig. 7 3D printed lightbulb module

The most commonly used element when teaching electric circuits is the lightbulb. That’s why it was the first module made.

Even switches are custom made. We respect the „see-inside principle“ here as well.

Fig. 8 Switches

Instead of copper tape we now use wires with magnetic ends to connect to modules. They are user-friendly for teachers to use in front of class.

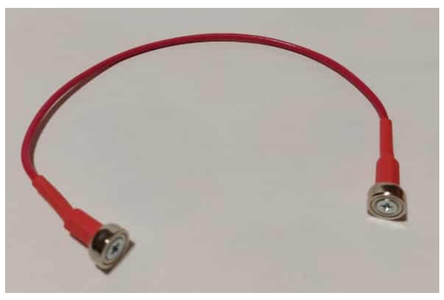
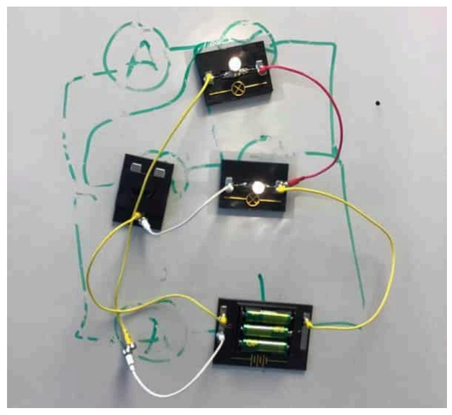


Fig. 9 Magnetic wire



While teaching you can first draw the electric-circuit (wiring) diagram on the board, then put the element modules of the elements on the corresponding symbol and finally connect the wires.

Fig. 10 Circuit on a whiteboard