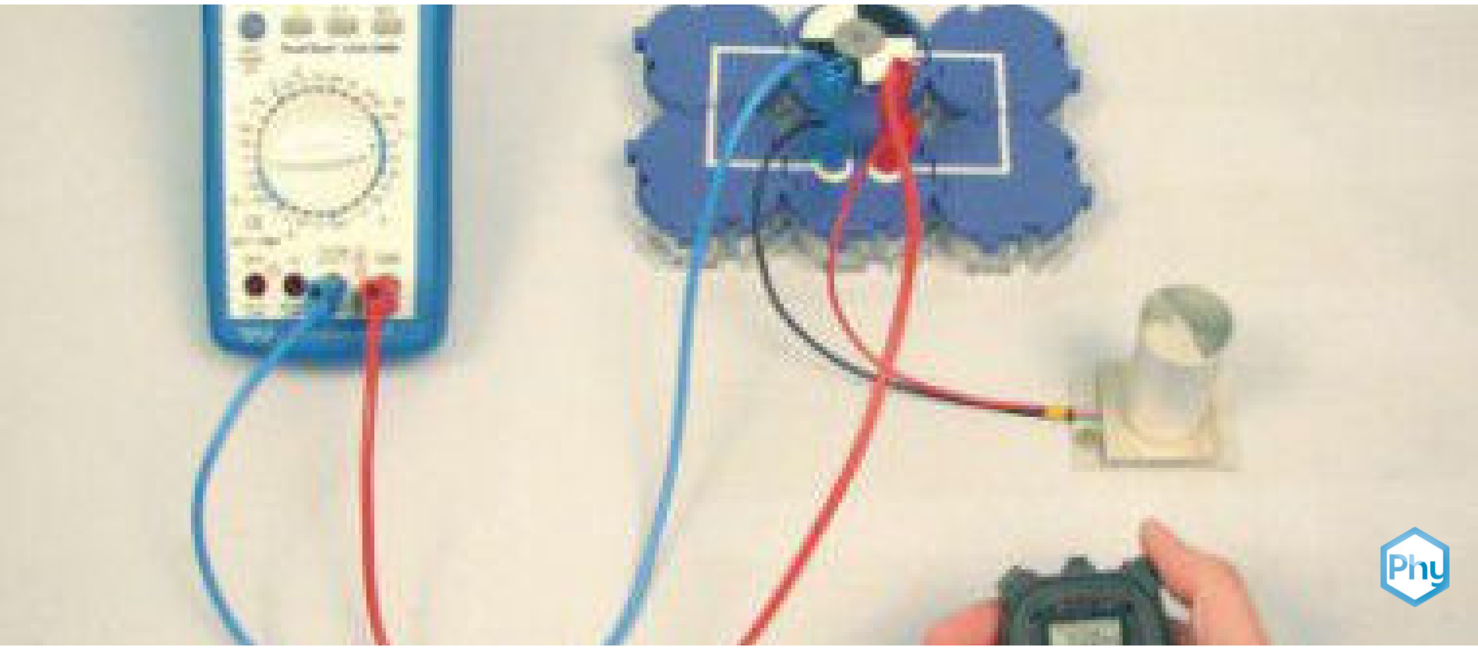
# Generation of electrical energy using a thermogenerator (thermoelectric power)



Physics | Energy | Renewable energies: Earth

| Difficulty level | Group size | Preparation time | Execution time |
|---|---|---|---|
| easy | 1 | 10 minutes | 10 minutes |

This content can also be found online at:

http://localhost:1337/c/62e814cc99933e00032706b3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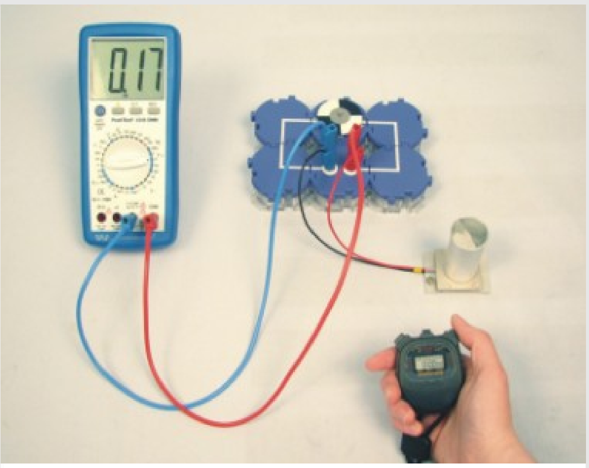
# Teacher information

## Application



Experimental setup

The Peltier element (the thermogenerator) consists of many thermocouples. These are connected electrically in series and thermally in parallel so that their thermoelectric voltages add up.

This experiment shows that a thermogenerator can generate electrical energy from thermal energy. The thermoelectric voltage of a thermogenerator depends on the temperature difference across the element.

A large storage tank (aluminium block) can keep the temperature difference stable (and thus higher) over a longer period of time and therefore has advantages in energy production.



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## Other teacher information (1/3)

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**Prior knowledge**

Students should be familiar with the basic concepts of thermodynamics.

**Principle**

In this experiment, a Peltier element is put into operation and investigated to see how it produces an electric current and what properties this current has.

## Other teacher information (2/3)

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**Learning objective**

Students learn how to generate electricity with a thermogenerator.

**Tasks**

- The thermogenerator consists of a so-called "Peltier element", which is mounted between two thin aluminium plates.
- Observe what happens when the aluminium plates are heated or cooled.
- Try to run a small motor with the thermogenerator.
- In addition, there is a large aluminium block. Investigate what significance it has.



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## Other teacher information (3/3)

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**Notes on set-up and procedure**

The experiment consists of several small experiments. Make sure to leave enough time between these experiments for the two sides of the thermogenerator to cool down to room temperature again and thus for the thermoelectric voltage to approach zero.

For each group of students, provide small pieces of ice that fit into the blank aluminium cup.

The results depend on the ambient temperature, so the measured values may deviate from the sample solution. However, the general course of the thermoelectric voltage remains the same.

## 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

A campfire

Heat is one of the most intuitive and ubiquitous forms of energy and is also a by-product of almost all physical processes.

Using thermogenerators, it is possible to convert this common form of energy into electricity and meet the ever-growing demand for electronics in everyday life.

A typical example of a thermogenerator is the Peltier element, which uses temperature differences to generate a current flow.



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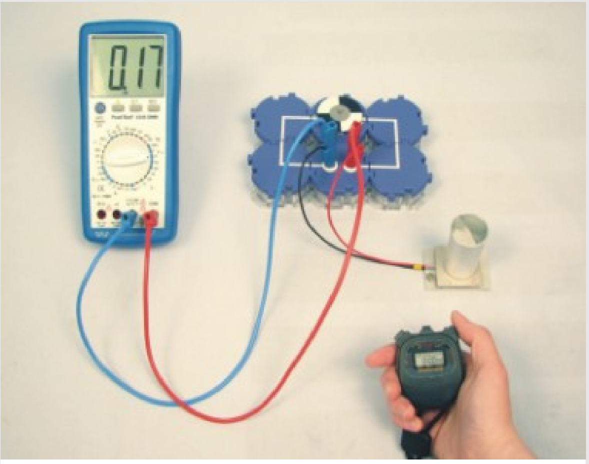
## Tasks



The experimental setup

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Observe what happens when the aluminium plates are heated or cooled.

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# Equipment

| Position | Material | Item No. | Quantity |
|---|---|---|---|
| 1 | Thermal generator for student experiments | 05770-00 | 1 |
| 2 | Motor with indicating disc, SB | 05660-00 | 1 |
| 3 | Angled connector module, SB | 05601-02 | 4 |
| 4 | Interrupted connector module with sockets, SB | 05601-04 | 1 |
| 5 | Beaker, aluminum, polished | 05903-00 | 1 |
| 6 | Beaker, 100 ml, plastic (PP) | 36011-01 | 1 |
| 7 | Lab thermometer,-10..+110 °C | 38056-00 | 1 |
| 8 | Digital stopwatch, 24 h, 1/100 s and 1 s | 24025-00 | 1 |
| 9 | Connecting cord, 32 A, 500 mm, red | 07361-01 | 1 |
| 10 | Connecting cord, 32 A, 500 mm, blue | 07361-04 | 1 |
| 11 | PHYWE Digital multimeter, 600V AC/DC, 10A AC/DC, 20 MΩ, 200 µF, 20 kHz, −20°C…760°C | 07122-00 | 1 |



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## Set-up

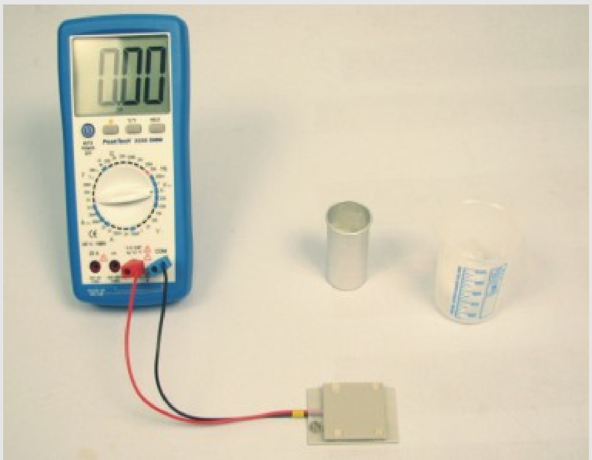

Figure 1

**1.** You need small pieces of ice for the experiment. Keep them in the 100 ml beaker.

**2.** Fill the blank cup full with small ice cubes and add some melted water or cold water (the cup should be filled no more than halfway with water).

**3.** Place the thermogenerator on the table so that the larger plate is at the bottom and connect the element to the voltage input of the meter (Fig. 1). Select the DC voltage measuring range 2V-.

## Procedure (1/3)

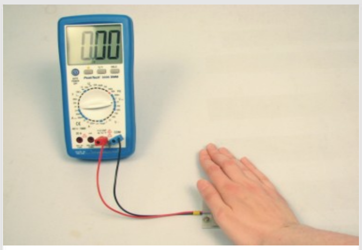

Figure 2

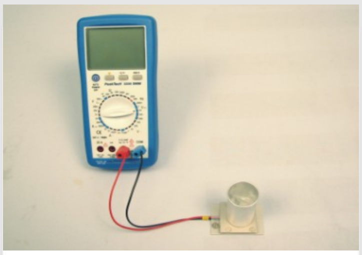

Figure 3

**1.** Only touch the upper plate of the thermogenerator with your hand (Fig. 2). Note in the report whether the indicated voltage is positive or negative.

**2.** Wait until the voltage is approximately between -10 mV and +10 mV again.

Place the blank beaker with ice on the thermogenerator (Fig. 3). Observe and note whether the voltage displayed is positive or negative and take the beaker back off the thermogenerator.

**3.** Turn the thermogenerator over so that the smaller plate is on the table. Wait until the voltage is again approximately between -10 mV and + 10 mV. Now repeat the experimental steps just described.



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## Procedure (2/3)

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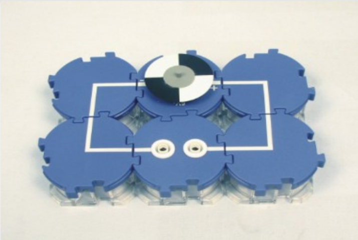

Figure 4

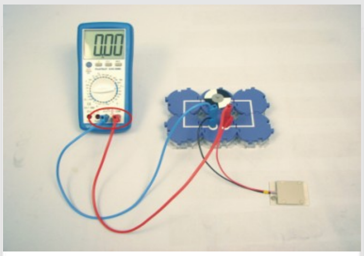

Figure 5

**4.** Build the circuit for the motor according to Figure 4.

**5.** Place the thermogenerator on the table so that the larger plate is at the bottom. Connect the motor and the thermogenerator according to Figure 5.

Swap the voltage inputs on the meter so that positive values are displayed.

**6.** Stir the ice water in the blank beaker until the thermometer shows about 0 °C to 1 °C (fig. 6). Add a few pieces of ice if necessary.

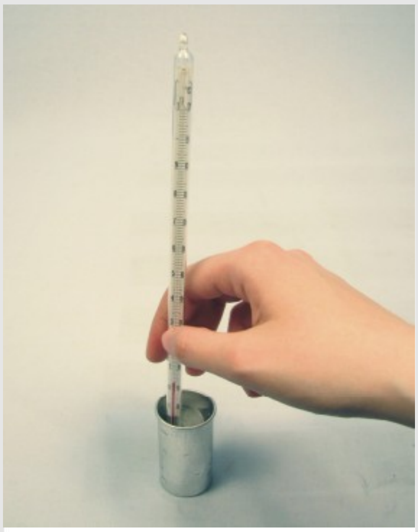

Figure 6

## Procedure (3/3)

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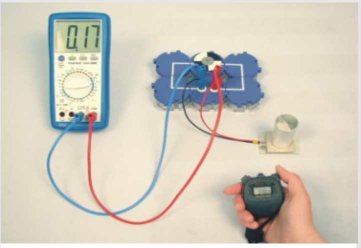

Figure 7

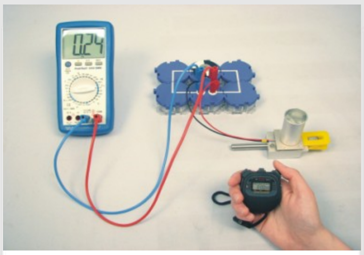

Figure 8

**7.** Place the cup on the thermogenerator and start the stopwatch (Fig. 7). Observe the meter and the motor, possibly prodding the motor. Note the voltage and your observation at 15 s intervals.

**8.** Take the beaker from the thermogenerator. Warm the thermogenerator back up to room temperature with your hands and wait until the voltage is approximately between -10 mV and +10 mV again. Place the thermogenerator on the aluminium block and clamp it.

Observe the voltage and possibly wait again for it to return to zero.

Stir the ice water in the beaker again and place the beaker on the thermogenerator with aluminium block (Fig. 8).

**9.** Repeat the experiment and note down the results.



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# Report

## Task 1

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### Drag the words into the correct gaps

The ______ is used to create a temperature difference between two ______ via the Peltier effect. To do this, an ______ must be passed through the semiconductor plates. However, it is possible to reverse this effect by first creating the ______ and then generating the current flow from it. This phenomenon is called the ______.

- Peltier element
- Seebeck effect
- electrical current
- temperature difference
- semiconductor plates

Check



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## Task 2

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**What does the material- and temperature-dependent Seebeck coefficient describe?**

$S_m(T)$ = $\frac{\square}{\square}$

| | | |
|---|---|---|
| $t$ | $\eta$ | $v$ |
| $U$ | $A$ | $\rho$ |
| $I$ | $\Delta T$ | $m$ |

$t$ = Time, $\eta$ = efficiency, $v$ = speed, $U$ = Voltage, $A$ = contact surface,$\rho$ = Air density, $I$ = current intensity, $\Delta T$ =temperature difference, $m$ = mass

Check

## Task 3

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**Which two of these equations describe the voltage $U$ in a Peltier element?**

- ☐ $U = \frac{S_1 - S_2}{\Delta T}$
- ☐ $U = \int_{\Delta T}(S_1(T) - S_2(T))dT$
- ☐ $U = (S_1 - S_2) \cdot \Delta T$ at constant outside temperature and small $\Delta T$
- ☐ $U = \frac{S_1}{S_2}$

Check



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| Slide | Score / Total |
|---|---|
| Slide 16: Seebeck effect phenomenon | 0/5 |
| Slide 17: Seebeck coefficient | 0/2 |
| Slide 18: Peltier element | 0/2 |

Total 0/9

Solutions Repeat



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