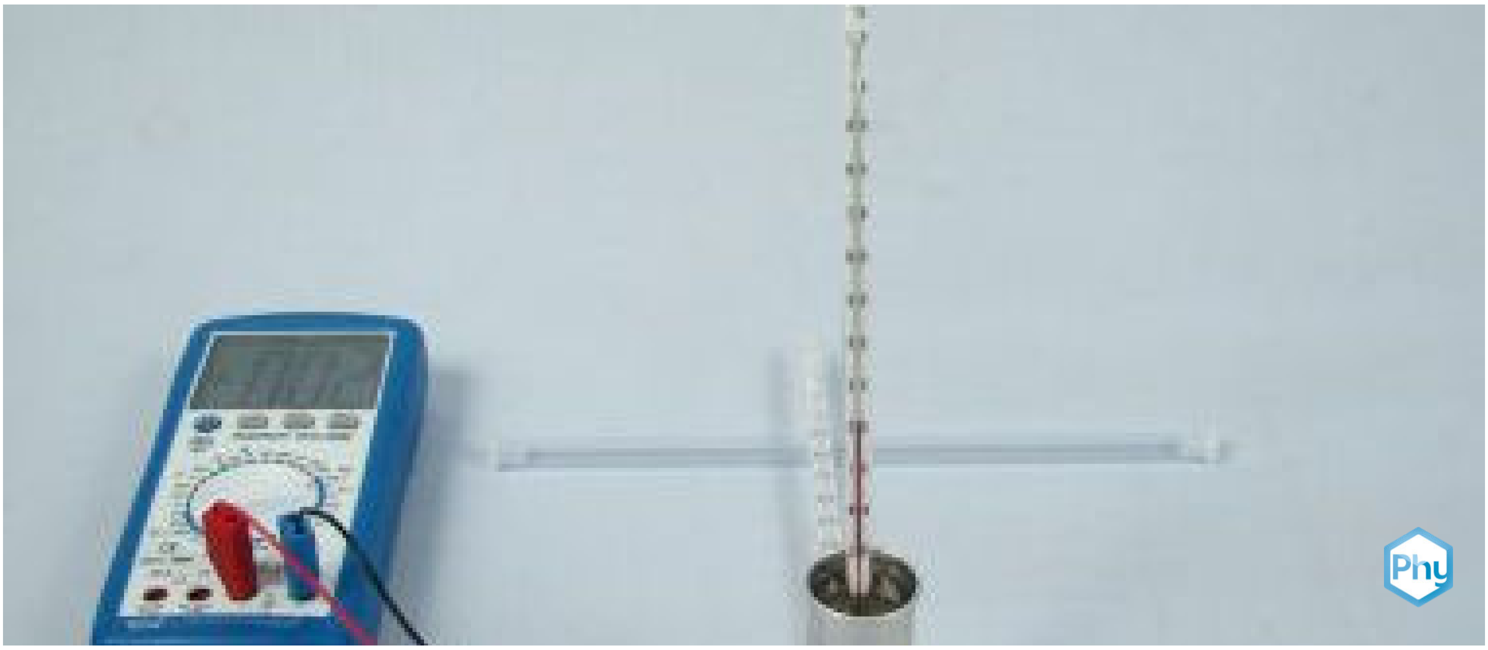
Thermal voltage and temperature



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/62e814db99933e00032706b7

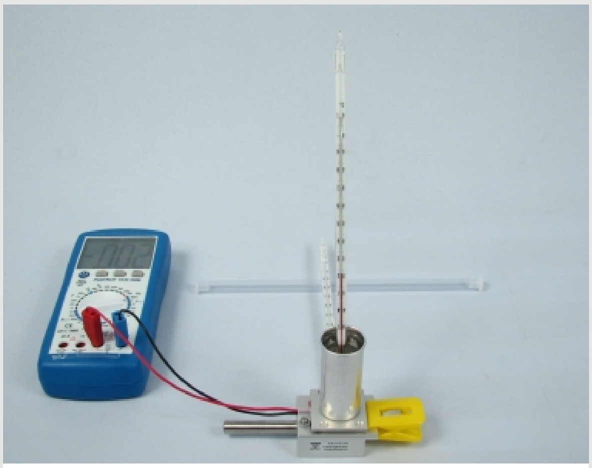
Robert-Bosch-Breite 10
37079 Göttingen
Tel.: 0551 604 - 0
Fax: 0551 604 - 107
info@phywe.de
www.phywe.de

PHYWE

Teacher information

Application

PHYWE



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.

PHYWE
Robert-Bosch-Breite 10
37079 Göttingen
Tel.: 0551 604 - 0
Fax: 0551 604 - 107
info@phywe.de
www.phywe.de

Other teacher information (1/3)

PHYWE

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)

PHYWE

Learning objective

Students learn how temperature affects the current generated by a thermogenerator.

Tasks

Investigate the relationship between the thermoelectric voltage and the temperature difference across the thermogenerator.

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

Other teacher information (3/3)

PHYWE

Notes on set-up and procedure

Care must be taken that the thermometer in the aluminium block has good contact with the metal during the experiment and does not wobble. Therefore, it is suggested to place it on the protective sleeve. Better contact and fixation and thus more accurate temperature readings can be achieved with the help of thermal paste.

However, since in this experiment only a proportionality between the temperature difference and the thermoelectric voltage is to be shown, in which the proportionality constant is secondary, the thermal paste is not necessary.

Safety instructions

PHYWE

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

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

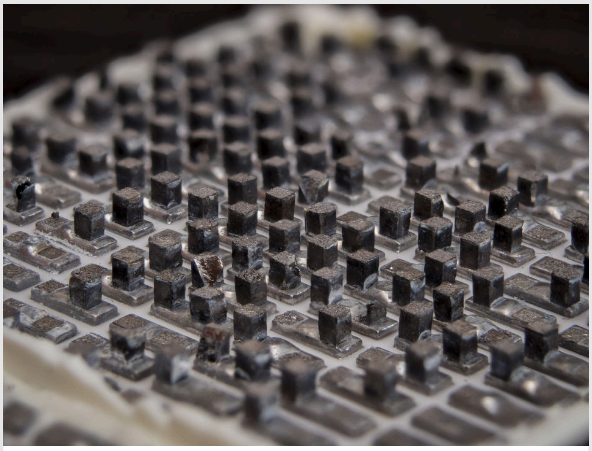
info@phywe.de
www.phywe.de

PHYWE

Student information

Motivation

PHYWE



Close-up of the cuboid semiconductors of a broken Peltier element

Temperature is nothing more than a statistical description of the average kinetic energy of the molecules and atoms of a material. The warmer a material, the faster the atomic bonds move.

So there is an energy difference between a cold substance and a warm substance.

In this experiment, the effects of this temperature difference on the conversion to electric current by a thermogenerator, such as the Peltier element, are examined in more detail.

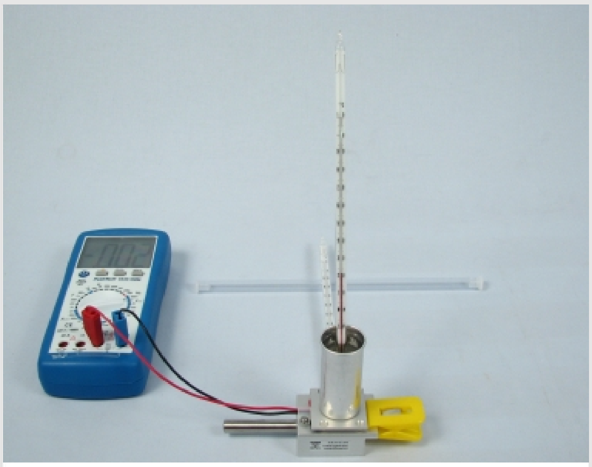
PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

Tasks



The experimental setup

Investigate the relationship between the thermoelectric voltage and the temperature difference across the thermogenerator.

Robert-Bosch-Breite 10
37079 Göttingen
Tel.: 0551 604 - 0
Fax: 0551 604 - 107
info@phywe.de
www.phywe.de

Equipment

Position	Material	Item No.	Quantity
1	Thermal generator for student experiments	05770-00	1
2	Beaker, aluminum, polished	05903-00	1
3	Lab thermometer,-10..+110 °C	38056-00	2
4	Digital stopwatch, 24 h, 1/100 s and 1 s	24025-00	1
5	Beaker, Borosilicate, low-form, 400 ml	46055-00	1
6	PHYWE Digital multimeter, 600V AC/DC, 10A AC/DC, 20 MΩ, 200 µF, 20 kHz, −20°C…760°C	07122-00	1

PHYWE
Robert-Bosch-Breite 10
37079 Göttingen
Tel.: 0551 604 - 0
Fax: 0551 604 - 107
info@phywe.de
www.phywe.de

Set-up (1/2)

PHYWE

1. The thermogenerator consists of the aluminium block, the Peltier element and the yellow clamp. Place the aluminium block with the back on the table (Fig. 1).

2. Attach the Peltier element to the aluminium block using the yellow clip (Fig. 2).

3. Connect the thermogenerator to the multimeter and use the DC voltage range up to 2 V (Fig. 3 and Fig. 4).

Figure 1

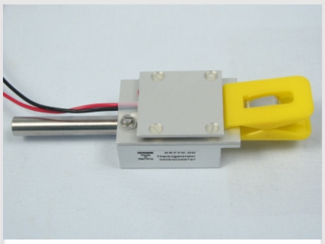


Figure 2

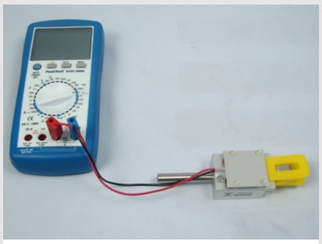


Figure 3

Figure 4

Set-up (2/2)

PHYWE

4. On one side of the aluminium block there is an opening for temperature measurement (Fig. 5).

5. Insert one of the two thermometers into this opening and make sure that the measuring tip of the thermometer touches the aluminium block (Fig. 6).

6. To prevent the thermometer from slipping out of the opening during the experiment, you can place the other end of the thermometer, for example, on the sheath in which it is kept in the box (Fig. 7).

7. Place the cup on the Peltier element (Fig. 8).

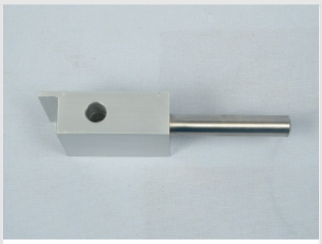


Figure 5

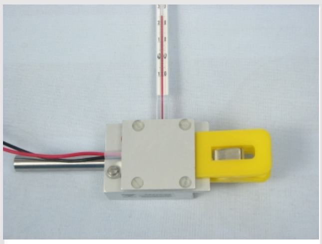


Figure 6

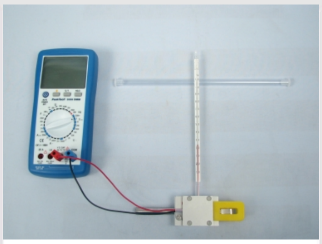


Figure 7

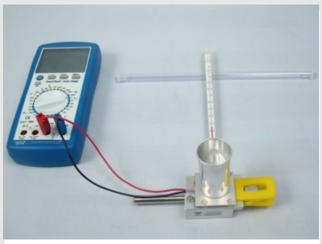


Figure 8

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

Procedure

PHYWE

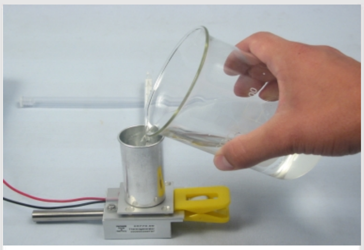


Figure 9

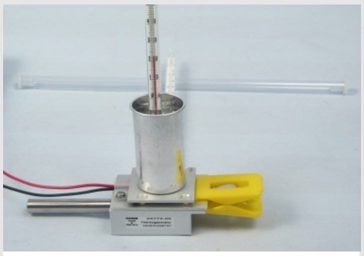


Figure 10

1. Have your teacher put hot water in your beaker. Measure the temperature of the water with the second thermometer. When the water has cooled down to about 55°C, you can pour it into the beaker until it is almost filled to the top (Fig. 9).

2. Now place the thermometer you used to measure the temperature of the water in the beaker without letting the water overflow (Fig. 10).

3. Make sure that you can read the temperatures on both thermometers without touching them. Now start the stopwatch and measure the thermoelectric voltage U every minute for 15 minutes on the thermogenerator, the temperature ϑ_1 of the water and the temperature ϑ_2 of the aluminium block and note the values.

PHYWE

Report

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

Task 1

PHYWE

Drag the words into the correct gaps

Temperature affects ____________ in several different ways. Firstly, the ability of a material to generate a thermocurrent, described by the ____________, is temperature dependent. To calculate the thermoelectric voltage, one must integrate the ____________ of the two temperature-dependent Seebeck coefficients over the ____________.

- Seebeck coefficient
- temperature difference
- thermoelectricity
- difference

Check

Task 2

PHYWE

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

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

t	η	v
U	A	ρ
I	ΔT	m

Check

t = Time, η = efficiency, v = speed, U = Voltage, A = contact surface
ρ = Air density, I = current intensity, ΔT =temperature difference, m = mass

PHYWE
Robert-Bosch-Breite 10
37079 Göttingen
Tel.: 0551 604 - 0
Fax: 0551 604 - 107
info@phywe.de
www.phywe.de

Task 3

PHYWE

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

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

Check

Task 4

PHYWE

For simplicity, assume that $S_{Alu}(T) = 3.5\frac{\mu V}{k}$ and $S_{Rod}(T) = 6\frac{\mu V}{k}$.

Now calculate the thermoelectric voltage between rodium and aluminium with the temperatures $T_{Rod} = 250K$and $T_{Alu} = 240K$.

Result: ______ μV

Check

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

Task 5

PHYWE

On which properties does the Seebeck coefficient of a material depend?

- [ ] Temperature
- [ ] Specific heat capacity
- [ ] Thermal conductivity
- [ ] State density
- [ ] Transmission rate

Check

Slide	Score / Total
Slide 15: Thermoelectric voltage	**0/4**
Slide 16: Seebeck coefficient	**0/2**
Slide 17: Peltier element	**0/2**
Slide 18: Arithmetical problem	**0/1**
Slide 19: Material and Seebeck coefficient	**0/2**

Total **0 / 11**

Solutions Repeat

PHYWE
Robert-Bosch-Breite 10
37079 Göttingen
Tel.: 0551 604 - 0
Fax: 0551 604 - 107
info@phywe.de
www.phywe.de