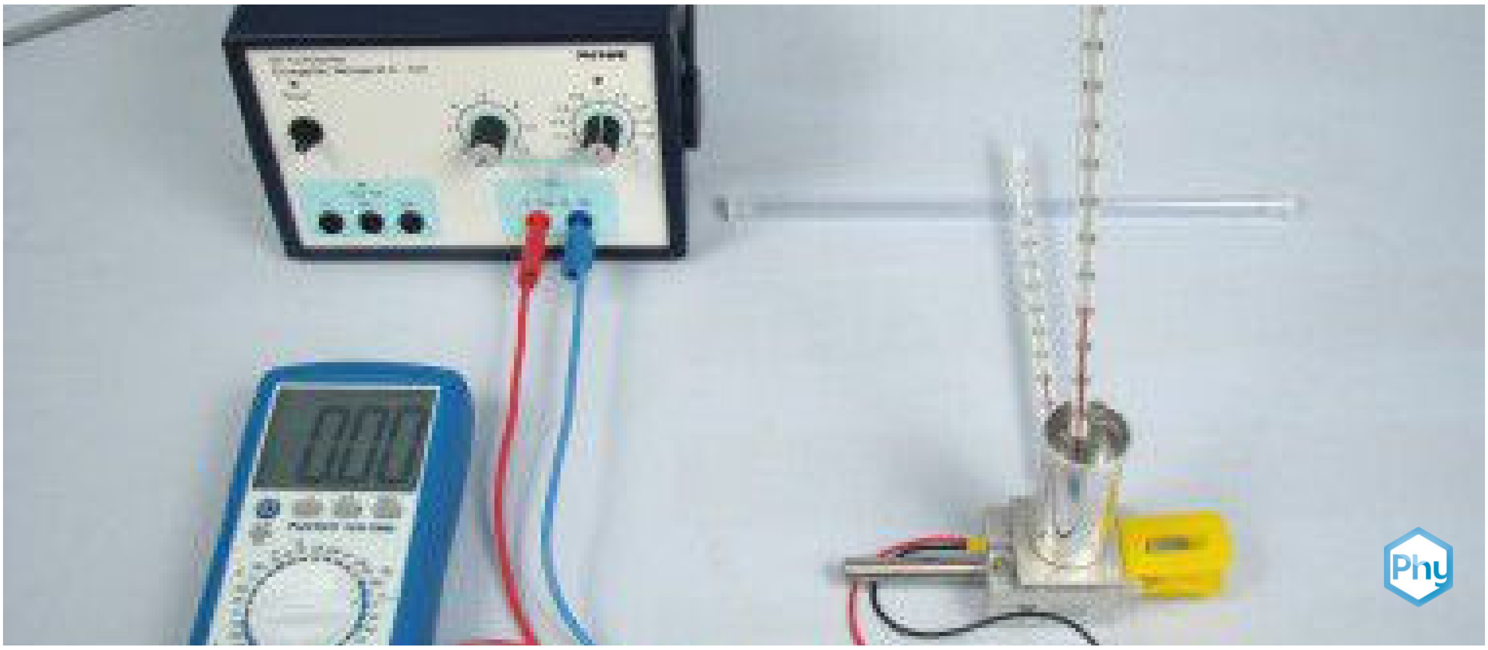
Peltier effect: heat pump



Physics	Thermodynamics	Conversion of heat, entropy
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/62e814fb99933e00032706c0

Teacher information

Application

Experimental setup

A heat pump is a machine that uses mechanical or electrical energy to pump thermal energy from a medium A to a medium B.

The heat supplied to the medium B Q is greater than the mechanical or electrical energy expended E_0.

The quality of a heat pump is determined by the so-called performance number $\epsilon = Q/E_0$.

$\epsilon > 1$ always applies.

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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 it is investigated how much heat separation takes place per electrical energy expended and what other physical processes occur.

Other teacher information (2/3)

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Learning objective

The students learn how a Peltier element can be used to transport heat.

Tasks

A cup of water is placed on the upper plate of the thermogenerator. Apply a voltage to the thermogenerator and choose the polarity so that the upper plate and thus the water heats up.

Determine the electrical energy used and the thermal energy gained.

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Other teacher information (3/3)

Notes on set-up and procedure

Before switching on the power supply unit, it should be checked on the multimeter that both plates of the Peltier element have the same temperature, i.e. the thermoelectric voltage at the thermogenerator should ideally be 0 V. Furthermore, the students can use the multimeter to set the current control on the power supply unit to exactly 1 A before the measurement.

Safety instructions

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

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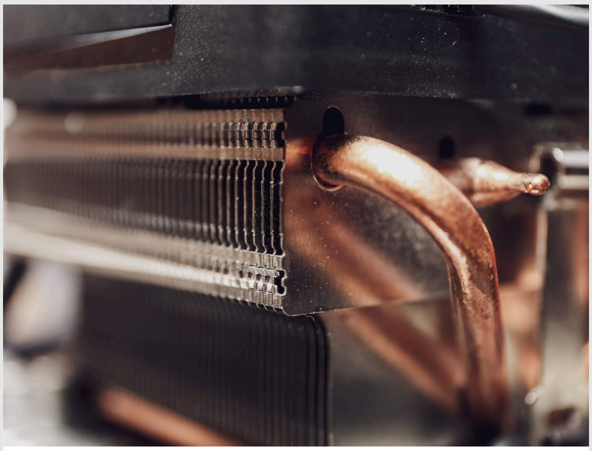
Student information

Motivation



A heat conduction

Heat pumps can be used to transfer the heat energy of one object into another object by applying energy. This allows the heat of an object that is difficult to cool (e.g. microprocessors) to be pumped into materials that are built for heat dissipation.

Heat from a medium that is easy to heat can also be transferred to a medium that is difficult to heat. The application possibilities are therefore numerous.

This principle is examined in more detail in this experiment using a Peltier element, which exploits semiconductor properties to carry out heat transport under current flow.

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Tasks

The experimental setup

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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	Beaker, 100 ml, plastic (PP)	36011-01	1
5	Digital stopwatch, 24 h, 1/100 s and 1 s	24025-00	1
6	Double sockets,1 pair,red a.black	07264-00	1
7	Connecting cord, 32 A, 250 mm, red	07360-01	2
8	Connecting cord, 32 A, 250 mm, blue	07360-04	2
9	PHYWE Power supply, 230 V, DC: 0...12 V, 2 A / AC: 6 V, 12 V, 5 A	13506-93	1
10	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 (1/3)

1. Attach the Peltier element to the aluminium block using the yellow clamp (Fig. 1). Note that the smaller side of the Peltier element is on top.

2. Now connect the thermogenerator to the power supply unit using the two double sockets and the cables (Fig. 2). The power supply unit is switched off. Make sure that the red cable of the thermogenerator is connected to the negative pole of the power supply unit (blue socket) and the black cable to the positive pole (red socket).

3. Turn the current regulator up to 1 A and the voltage regulator all the way up (fig. 3).

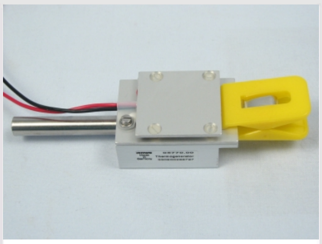
Figure 1

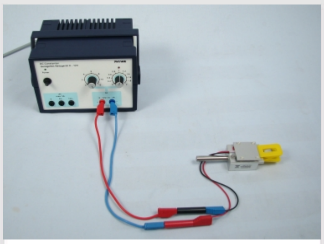
Figure 2

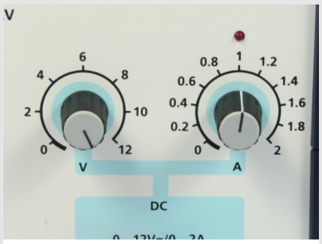

Figure 3

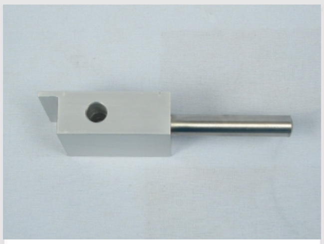
Figure 4

Set-up (2/3)

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

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

6. It might be helpful to place the other end of the thermometer, for example, on the sheath in which it is kept in the box (Fig. 6).

7. Control measurements with an infrared thermometer are useful (Fig. 7).

8. Now dip the second thermometer into the water (Fig. 8).

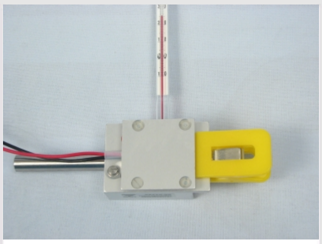
Figure 5

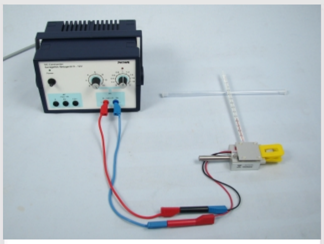
Figure 6


Figure 7

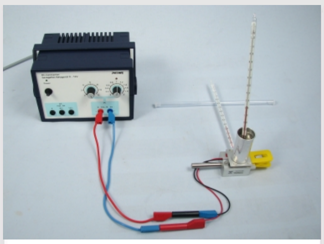
Figure 8

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Set-up (3/3)

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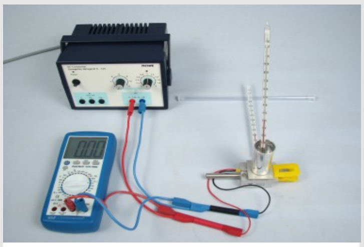

Figure 9

8. Now connect the multimeter in parallel to the thermogenerator (Fig. 9).

9. Set the measuring range to 20V DC (Fig. 10).

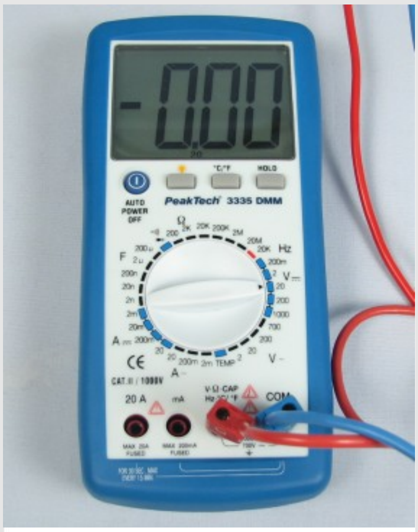

Figure 10

Procedure

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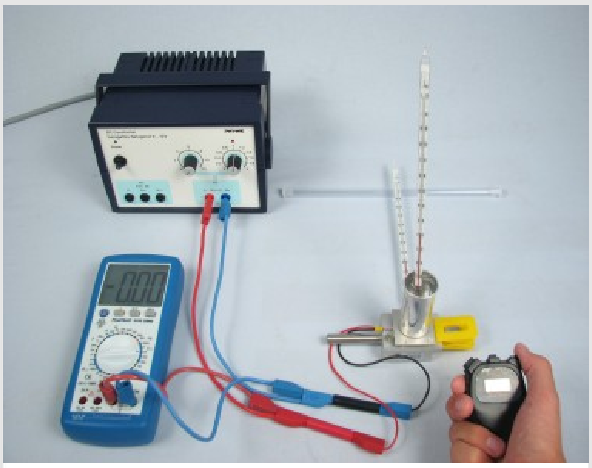

Figure 11

1. Switch on the power supply unit and measure the voltage U, the temperature ϑ_1 of the water and the temperature ϑ_2 of the aluminium block directly after switching on (t = 0 min).

2. Start the stopwatch and then measure U, ϑ_1 and ϑ_2 after t = 1,2,3,4,5 min and note the values in your report (Fig. 11).

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Report

Task 1

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Which equation for ϵ is true?

- $\epsilon = \frac{\Delta Q}{E_0 \cdot R}$
- $\epsilon = \frac{Q}{E_0}$
- $\epsilon = \Delta Q \cdot E_0$
- $\epsilon = \frac{1}{2} E_0 \cdot \Delta Q$

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Task 2

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ϵ is always greater than 1. What does this mean graphically?

- ϵ describes how much faster the heat is transported compared to dispersion in the air. $\epsilon = 1,5$ would therefore mean that the heat passes 1.5 times the distance it would have travelled naturally in the air.
- ϵ describes how much heat is transported per energy expended. Since more heat energy is transported than electrical energy is expended, the system extracts energy from the environment and thus cools it down.
- There is no such thing as a perpetual motion machine. Energy processes are never perfectly efficient and ϵ describes how much more electrical energy you have to spend in proportion to move heat energy to compensate for the energy lost to the environment.

Task 3

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Drag the words into the correct gaps

The ______ η of a heat pump describes how efficiently it uses ______ to transport heat and is calculated from the ______ between the useful power (how much physical work was ultimately done) and the supplied power. This is an important industrial measure for heat pumps to minimise ______.

- energy
- ratio
- energy waste
- effectiveness

Check

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Slide	Score / Total
Slide 16: Performance figure	0/1
Slide 17: Heat transport	0/1
Slide 18: Efficiency	0/4

Total 0 / 6

Solutions Repeat

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