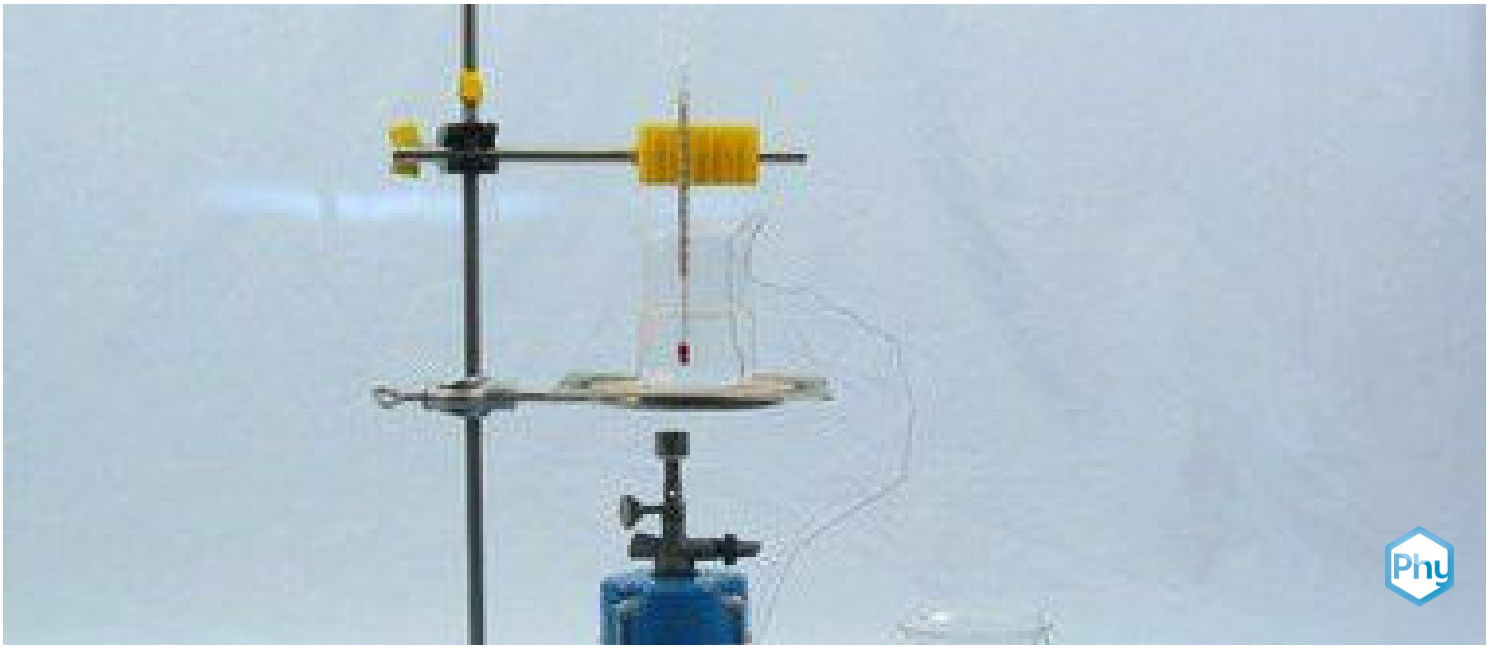
Temperature measurement with a thermocouple



P1042400

Physics > Thermodynamics > Temperature & Heat

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

This content can also be found online at:

http://localhost:1337/c/6409f8486ce50200020bbd0c

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Teacher information

Application

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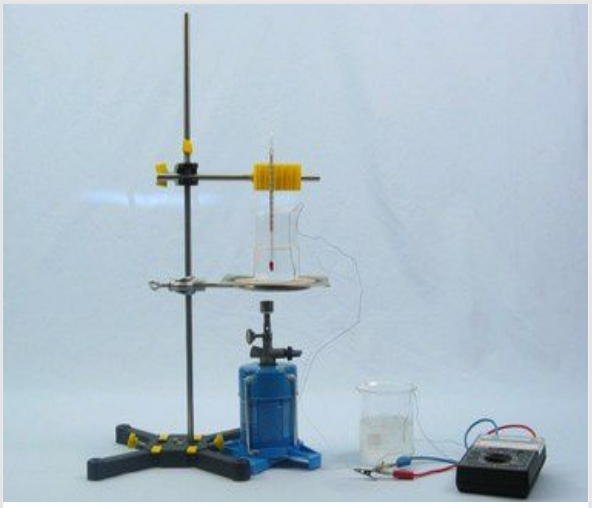

Experimental setup

If two different metals touch each other, a contact voltage occurs due to the different work function of the electrons leaving the metal surface. The size of this voltage depends on the temperature, because the electrons gain more kinetic energy with increasing temperature.

A thermocouple works according to this principle. Thus, with the help of such a thermocouple, the temperature can be measured. They can also be used at very high temperatures, such as when measuring the temperature of firing systems in industry or even a gas cooker in the kitchen.

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Other teacher information (1/3)

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Prior knowledge

Students should be familiar with both a butane burner, a thermometer and a voltmeter.

Principle

A thermocouple consists of a pair of different metals, e.g. iron and constantan. If you bring the two contact points of the thermocouple to different temperatures, you can measure the difference in contact voltage as the thermoelectric voltage. In this experiment, the students will do this for different temperature differences and the linear relationship between the temperature and the voltage will be established.

Other teacher information (2/3)

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Learning objective

In this experiment, the students should learn how a thermocouple works.

They should realise that when measuring with a thermocouple, 2 soldering points are always important, a measuring point and a reference point. (The reference junction is usually included in the connector of ready-made thermocouples).

You should observe that the thermoelectric voltage increases approximately linearly with temperature.

Task

How does a thermocouple work?

Make a thermocouple from iron wire and constantan wire and investigate how it can be used to measure temperatures.

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Other teacher information (3/3)

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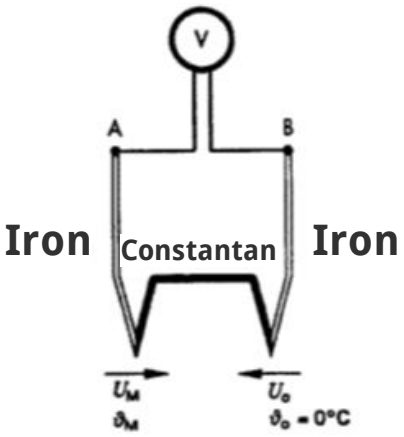
These voltages also occur when connecting a measuring instrument to a conductor. However, they cancel each other out (i.e. do not falsify the measurement result) if both leads to the measuring instrument are made of the same material.

If no thermoelectric voltages occur, check the quality of the contact points. The ends of the wires must be sufficiently rubbed bare. The twisted wires should possibly be pressed together with the help of a pair of combination pliers so that the two thermal wires have good contact.

The following applies: $V = -V_1 + V_M - V_0 + V$ and $V = V_M - V_0$



Sketch thermocouple

Safety instructions

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

When the water heats up, the tripod ring and the wire net become very hot!

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Student information

Motivation

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Gas cooker

Conventional thermometers, like the ones you have in your garden, are liquid-gas thermometers based on the thermal expansion of liquids. However, you can also measure temperature in another way - with a thermocouple. This method is used, for example, in gas cookers to check the temperature of the flame.

With the help of this experiment, you will learn how exactly this measurement works.

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Tasks

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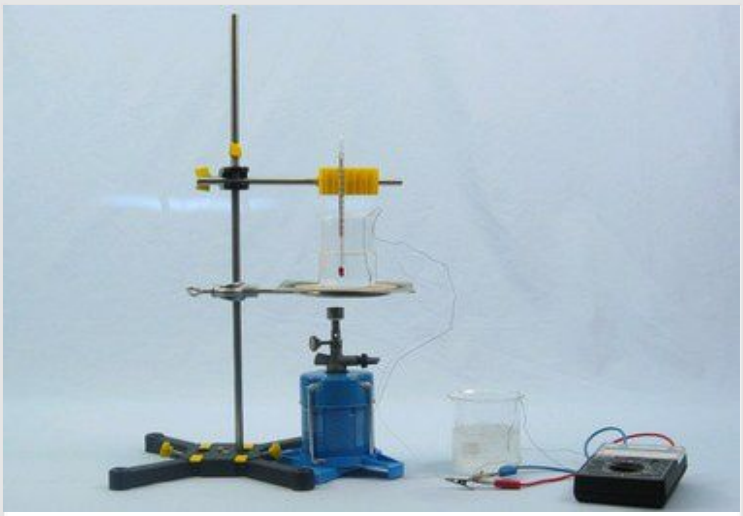

Experimental setup

How does a thermocouple work?

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Equipment

Position	Material	Item No.	Quantity
1	Support base, variable	02001-00	1
2	Support rod, stainless steel, l = 250 mm, d = 10 mm	02031-00	1
3	Support rod, stainless steel, l = 600 mm, d = 10 mm	02037-00	1
4	Boss head	02043-00	1
5	Glass tube holder with tape measure clamp	05961-00	1
6	Ring with boss head, i. d. = 10 cm	37701-01	1
7	Wire gauze with ceramic, 160 x 160 mm	33287-01	1
8	Agitator rod	04404-10	1
9	Beaker, Borosilicate, low form, 250 ml	46054-00	1
10	Beaker, Borosilicate, low-form, 400 ml	46055-00	1
11	Students thermometer,-10...+110°C, l = 180 mm	38005-02	1
12	PHYWE Digital multimeter, 600V AC/DC, 10A AC/DC, 20 MΩ, 200 µF, 20 kHz, −20°C…760°C	07122-00	1
13	Connecting cord, 32 A, 500 mm, red	07361-01	1
14	Connecting cord, 32 A, 500 mm, blue	07361-04	1
15	Alligator clips, bare, 10 pcs	07274-03	1
16	Butane burner, Labogaz 206 type	32178-00	1
17	Butane cartridge C206, without valve, 190 g	47535-01	1
18	Constantan wire, 4 Ohm/m, d = 0.4 mm, l = 50 m	06102-00	1
19	Iron wire, d = 0.5 mm, l = 50 m	06105-00	1
20	Boiling beads, 200 g	36937-20	1

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Set-up (1/6)

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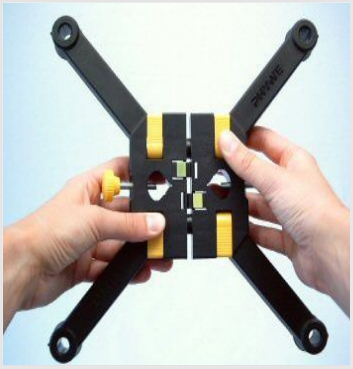
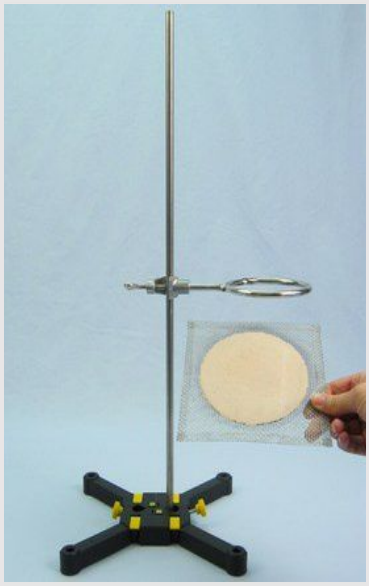
Set up the experiment according to the illustrations in order from left to right.




Set-up (2/6)

PHYWE

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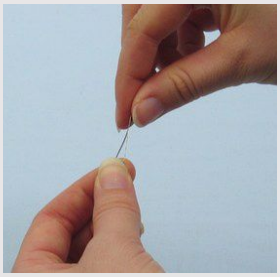
Set-up (3/6)

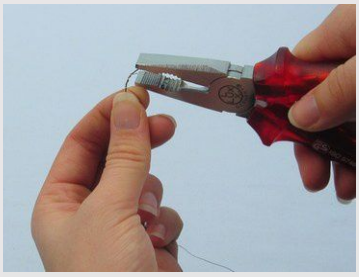
Cut 1 piece of constantan wire and 2 pieces of iron wire, each about 70 cm long.

Rub the ends of the wires bare with sandpaper.

Twist each end of the constantan wire tightly with an iron wire.



The twisted ends should still be pressed together with the help of a pair of pliers to improve the contact.



Set-up (4/6)

Crush ice with a hammer, wrapping it in a cloth first so that no splinters jump away.

Fill the large beaker about halfway with ice.

Add 2 boiling stones.

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Set-up (5/6)

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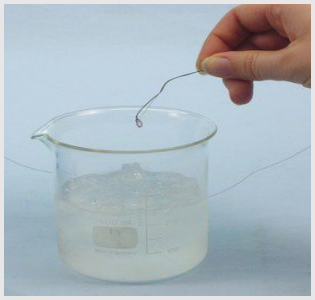
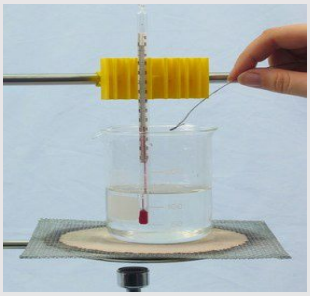
Add enough cold water to just cover the ice.

Fill the small beaker about halfway with tap water that is as cold as possible (below 20 °C).

- Put one contact point in the ice water, the other in the tap water, so that they are completely in water.
- Bend the wires over the edge of the cup so that they do not slip out.





Set-up (6/6)

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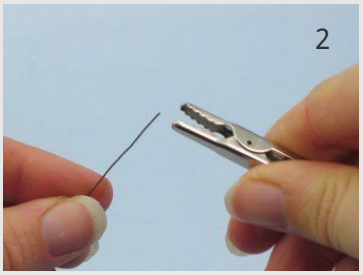
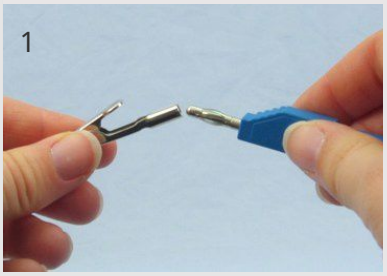
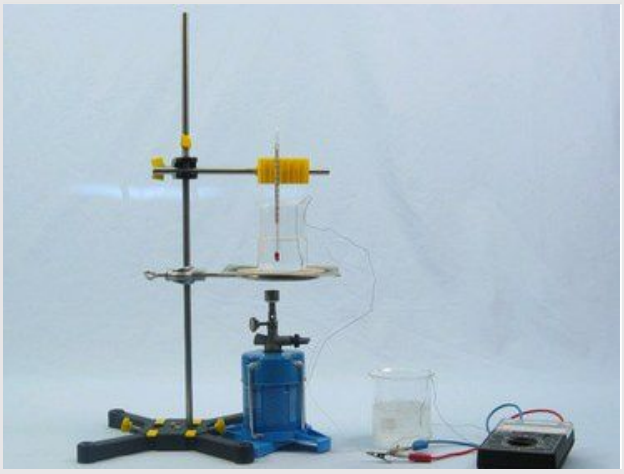
Connect the measuring instrument according to the following illustrations and set the DC voltage measuring range 100 mV.







Complete structure

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Procedure (1/2)

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Read off the displayed reading. Reverse the polarity of the meter if necessary. Heat the water until it boils. Stir so that the thermometer and the wire have the same water temperature. Measure the thermoelectric voltage in steps of 20 °C and enter the measured values in the table in the report.

Take the reference junction out of the ice water and hold it in the hot water as well (see figure on the right). Read the thermoelectric voltage and record the value in the report.

Procedure (2/2)

Immerse the reference junction in the ice water again. Hold the measuring point as completely as possible in the flame. Note the thermoelectric voltage.

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Report

Task 1

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1st experiment: The temperature of the reference junction is 0 °C (ice water). Enter the thermoelectric voltage in the table.

T in °C					
V in mV					

Plot your measurements on a graph with the voltage on the y-axis.

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Task 2

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2nd experiment: What happens to the thermoelectric voltage when both contact points are in hot water.

- ☐ The thermoelectric voltage quickly drops to zero.
- ☐ Nothing changes.
- ☐ The thermoelectric voltage drops quickly.
- ☐ The thermoelectric voltage increases rapidly.

Check

Experiment 3: Write down your reading

V in mV

Cold junction temperature: 0 °C (ice water)

Task 3

PHYWE

How can the relationship between the measured temperatures and thermoelectric voltages be described in words?

- The lower the temperature, the greater the thermoelectric voltage.
- The higher the temperature, the higher the thermoelectric voltage.
- The higher the temperature, the lower the thermoelectric voltage.

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Task 4

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What is the significance of the reference junction for the measured thermoelectric voltage?

- [ ] The thermoelectric voltage is independent of the temperature difference between the measuring point and the reference junction.
- [ ] The thermoelectric voltage is not dependent on the absolute value of the measuring point temperature.
- [ ] The thermoelectric voltage depends on the absolute value of the measuring point temperature.
- [ ] The thermoelectric voltage depends on the temperature difference between the measuring point and the reference junction.

Check

Task 5

PHYWE

Drag the words into the correct boxes!

The measurement curve from the diagram gives as the sensitivity of the thermocouple 1mV per _____, i.e. 0.05mV per _____ or 0.05mV/°C.
The temperature of the flame is about _____. Since the contact point of this simple thermocouple is relatively long, only the _____ of the flame temperature can be measured and not a temperature distribution.

average
1°C
20°C
400°C

Check

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Slide	Score / Total
Slide 21: Thermoelectric voltage	0/2
Slide 22: Relationship between temperature and thermoelectric voltage	0/1
Slide 23: Significance of the reference junction	0/2
Slide 24: Sensitivity of the thermocouple	0/4

Total 0 / 9

Solutions Repeat Export text

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