Thermal equilibrium with measureAPP (Item No.: P1042268)

Curricular Relevance

Area of Expertise: Physics
Education Level: Age 14-16
Topic: Thermal physics
Subtopic: Measurement of temperature
Experiment: Thermal equilibrium with measureAPP

Difficulty	Preparation Time	Execution Time	Recommended Group Size
Easy	10 Minutes	10 Minutes	2 Students

Additional Requirements:

- Apple iPad

Experiment Variations:

Keywords:

Heating, Temperature difference

Task and equipment

Information for teachers

When two bodies of different temperature have contact with each other, then temperature equalization takes place until both bodies have the same temperature (thermal equilibrium). The students should measure the temperature behaviour over time and thereby find that the change in temperature is greater the bigger the temperature difference is.

Notes on set-up and procedure

The water in the vessels is not stirred in this experiment. This is not necessary for a qualitative observation of the temperature behaviour. Temperature equalization is quicker when the water is stirred (see question 9.).

Caution!
The support ring and the wire gauze get very hot when the water is heated up! Hold the glass beaker at the upper rim when you pick it up to pour out hot water. Take care! Do not let the sensor cables touch the wire gauze!

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Set-up

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Task and equipment

Task

Application

Why do tea or coffee get cold on standing, but never hot? And why are ice cubes melting after taking them out of the freezer?

Kaffee kühlt durch Verdunstung ab.

Schmelzende Eiswürfel.

Task

Can a temperature difference be permanent?

Watch the water temperatures when a vessel containing cold water is dipped into a hot water bath.

Equipment

Position No.	Material	Order 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	Beaker, low, BORO 3.3, 250 ml	46054-00	1
9	Beaker, low, BORO 3.3, 400 ml	46055-00	1
10	Erlenmeyer flask 100 ml, wide-neck SB 29	36428-00	1
11	Butane burner, Labogaz 206 type	32178-00	1
12	Butane cartridge C206, without valve, 190 g	47535-01	1
13	Cobra4 Wireless/USB-Link incl. USB cable	12601-10	1
14	Cobra4 Sensor-Unit 2 x Temperature, NiCr-Ni	12641-00	1
15	Immersion probe NiCr-Ni, steel, -50...400 °C	13615-03	2

Position No.	Material	Order No.	Quantity
18	Apple iPad		1
19	PHYWE measure App		1

Set-up and procedure

Set-up

Fig. 1: Set-up

- Set the stand up as shown in Fig. 1.
- Fill 100 ml of cold water into the Erlenmeyer flask, then place the flask in the empty 400 ml glass beaker.
- Fix both temperature sensors in the glass tube holder. Adjust them so that one dips into the water in the Erlenmeyer flask and the other dips into the glass beaker to the same depth but does not touch the Erlenmeyer flask.

Procedure

Caution!
The support ring and the wire gauze get very hot when the water is heated up! Hold the glass beaker at the upper rim when you pick it up to pour out hot water. Take care! Do not let the sensor cables touch the wire gauze!

- Connect the Cobra4 Sensor-unit 2 x Temperatur with the Wireless/USB-link. Now connect both Immersion probes NiCr-Ni, steel, -50...400 °C with the Sensor-unit. Switch the Wireless/USB-link on.
- Connect your iPad via Wi-Fi with the Wireless/USB-link.
- Open the PHYWE measure App and select the sensor "2x temperature". Make sure that both measurement channels are activ.
- The preset sampling rate of 1 Hz is suitable for this experiment.
- Fill about 160 ml of water into the 250 ml glass beaker and heat it up to just below boiling, i.e. to about 80 °C. You can alternatively make the 160 ml of hot water available from a kettle.
- Pour hot water into the 400 ml glass beaker to the side of the Erlenmeyer flask until the beaker has about the same level as the water in the Erlenmeyer flask.
- Check that both temperature sensors dip into water.
- Start measured value recording in measureApp. Measure for about 8 minutes. For timing you can use the stoppwatch of the measureApp.
- After 8 minutes stopp the measurement, save and open it for further analysis under "my measurements".

Evaluation

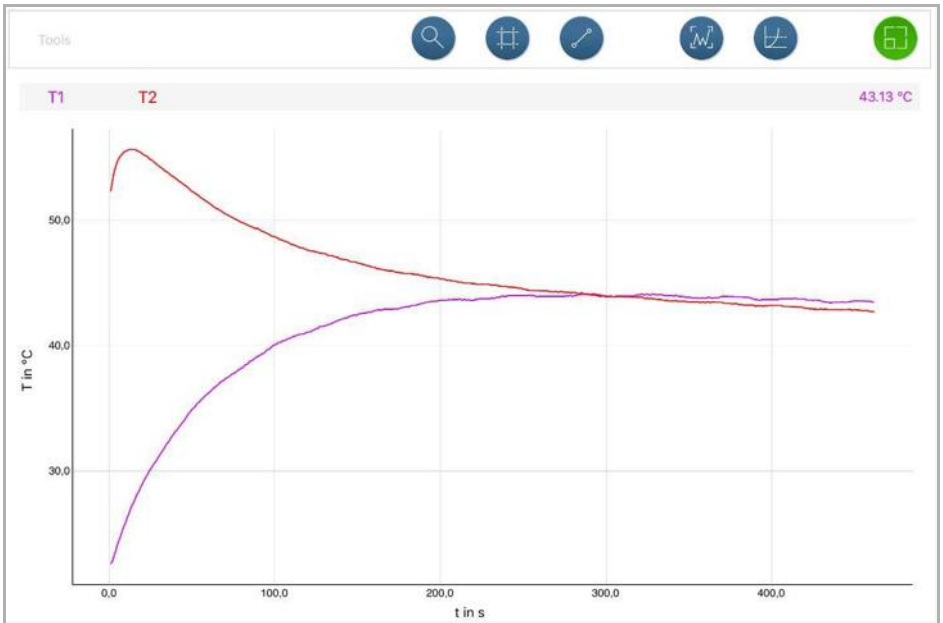

Fig. 2: Behaviour of the two temperatures with time.

Report: Thermal equilibrium with measureAPP

Evaluation - Question 1

Describe the behaviour of the two temperatures.

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Evaluation - Question 2

When the temperature of a substance changes, then the heat content of it also changes. From where to where does the heat content flow?

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Evaluation - Question 3

Does the temperature always change at the same speed?

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Evaluation - Question 4

The bigger the temperature difference, the ..... the change in temperature.

Evaluation - Question 5

What happens to the water temperatures after some time? Will there finally be a difference between them?

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Additional question 1

What can you learn about sudden jumps in temperature from the answer to question 1.? Under which conditions would it surprise you if they occurred?

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Additional question 2

Describe the temperature behaviour using the terms “heat“ and “inner energy“.

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Additional question 3

Would the temperature behaviour that was measured have been different if the water in one or both of the vessels had been stirred during measurement? What is the speed of the temperature change therefore also dependent on?

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