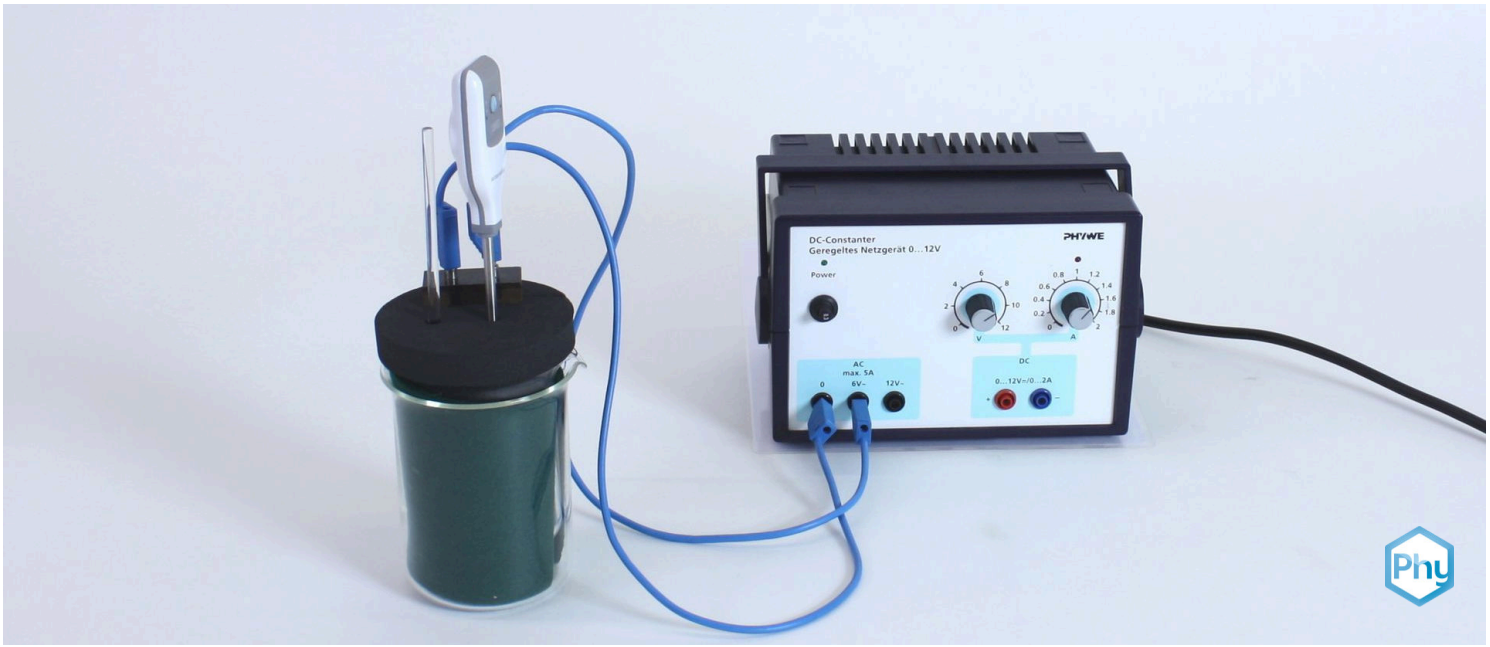
Heating of water with Cobra SMARTsense



Physics > Thermodynamics > Heat energy, thermal capacity

Difficulty level	Group size	Preparation time	Execution time
medium	-	10 minutes	30 minutes

This content can also be found online at:

http://localhost:1337/c/6565f73690a0de00022d8609

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Teacher information

Application

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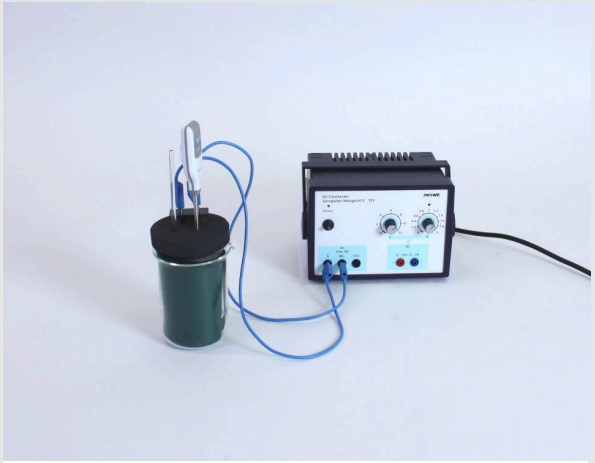

Experiment setup

Different quantities of water are heated with a heating coil at constant power in a calorimeter. The selected water quantities are matched to the size of the calorimeter (100 ml, 150 ml, 200 ml), and are in simple ratios to each other, so that it becomes obvious:

The more water, the slower the rate of temperature rise. For the same heating power, the rate of temperature increase is inversely proportional to the amount of water.

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Other teacher information (1/4)

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Prior knowledge

Students should be familiar with the basic concepts of thermodynamics and temperature.

Scientific Principle

In this experiment, different amounts of water are heated with constant energy and their temperature is observed via a heat sensor.

Based on this, statements are made about the behaviour of the temperature in relation to the given amount of water.

Other teacher information (2/4)

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Learning objective

Students learn how the temperature change of water depends on its quantity.

Tasks

Heat different amounts of water with an electric heating coil and measure the temperature increase as a function of time.

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Other teacher information (3/4)

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Notes on structure and implementation

- When the heating voltage of 12 V is switched on, the heating coil must be immersed in the water, otherwise it will glow through.
- To ensure that the initial temperatures are approximately the same, a 250 ml Erlenmeyer flask is used as a storage vessel for room temperature water.
- The water in the calorimeter must be stirred constantly to produce a nice smooth measurement curve.
- The temperature increase should not be chosen much higher, otherwise the heat losses due to incomplete insulation of the calorimeter will become noticeable.

Other teacher information (4/4)

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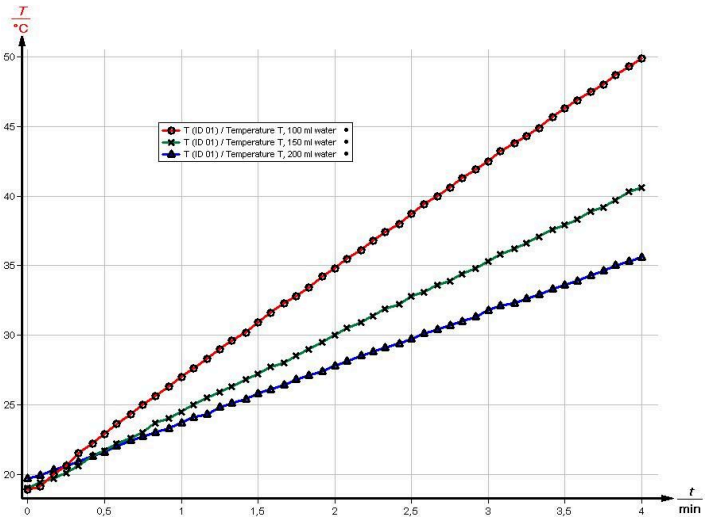
The adjacent figure shows the exemplary temperature curve for the different water quantities with the help of another software in order to clarify the correlations.



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Safety instructions

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

Attention!

The heating coil must be in water when a voltage of 12 V is applied. Otherwise it could burn out!

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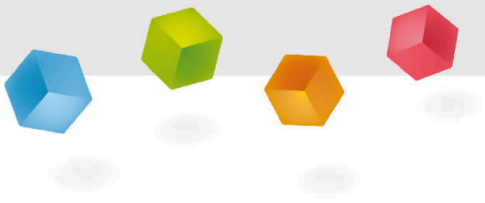

Student Information

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Motivation

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Boiling water

It's the first hot day of the year and to get a cooling later, I fill the paddling pool in the sun with water. While this is hopefully reasonably pleasant in the afternoon, it is still far too cold in the quarry pond around the corner.

This is because the amount of water that needs to be heated by the sun is much smaller in my paddling pool than it is in the quarry pond.

In this experiment you will now investigate the relationship between the amount of water and the time needed for heating.

Tasks (1/2)

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For measurement with the **Cobra SMARTsense sensors** the **PHYWE measureAPP** is required. The app can be downloaded free of charge from the relevant app store (see below for QR codes). Before starting the app, please check that on your device (smartphone, tablet, desktop PC) **Bluetooth** is **activated**.

iOS

Android

Windows

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Tasks (2/2)

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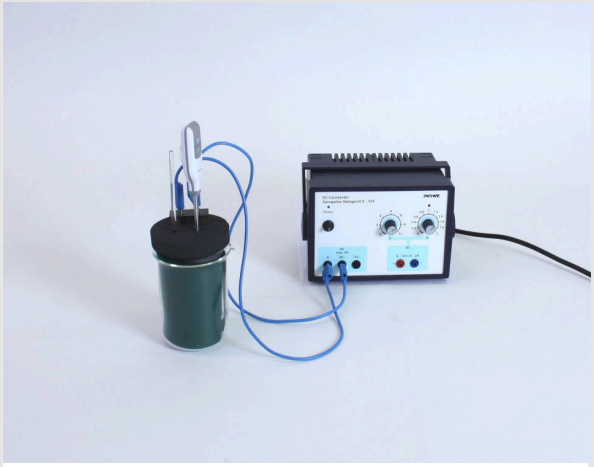

The experimental setup

How does the time it takes to heat water depend on the amount of water if a particular heating source is available?

Heat different amounts of water with an electric heating coil and measure the temperature increase as a function of time.

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Equipment

Position	Material	Item No.	Quantity
1	Lid for student calorimeter	04404-01	1
2	Agitator rod	04404-10	1
3	Heating coil with sockets	04450-00	1
4	Felt sheet, 100 x 100 mm	04404-20	2
5	Beaker, Borosilicate, low form, 250 ml	46054-00	1
6	Beaker, Borosilicate, low-form, 400 ml	46055-00	1
7	Erlenmeyer flask, borosilicate, wide neck, 250 ml	46152-00	1
8	Graduated cylinder 100 ml, PP transparent	36629-01	1
9	Pipette with rubber bulb	64701-00	1
10	Connecting cord, 32 A, 500 mm, blue	07361-04	2
11	PHYWE Power supply, 230 V, DC: 0...12 V, 2 A / AC: 6 V, 12 V, 5 A	13506-93	1
12	Cobra SMARTsense - Temperature, - 40 ... 120 °C (Bluetooth)	12903-00	1
13	measureAPP - the free measurement software for all devices and operating systems	14581-61	1

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Set-up

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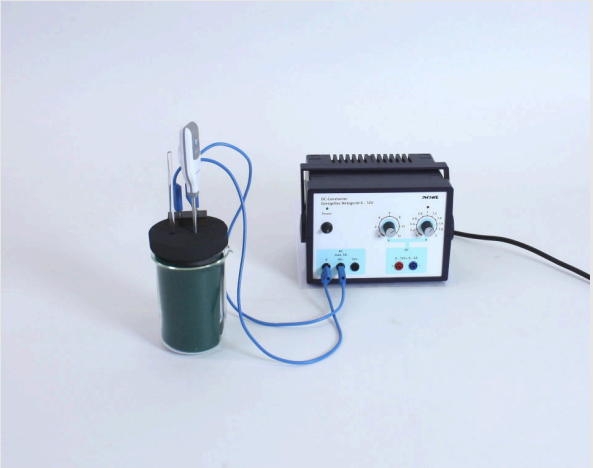

Figure 1

The experimental setup can be found in Fig. 1.

1. Assemble a heat-insulating vessel (calorimeter) from two beakers (250 ml and 400 ml) and two felt plates. It is best to place the felt plates on the edge of the larger beaker and then insert the smaller beaker.

2. Carefully slide the heating coil into the slot in the calorimeter lid.

3. Push the stirring rod from below through the corresponding hole in the lid. Make sure that the power supply unit is still switched off.

Procedure (1/5)

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1.Turn on your Cobra SMARTsense temperature sensor. Open the measure\ app app and select the temperature sensor.

2.Go to the diagram window .

3.Select a sampling rate of 1Hz under Settings and switch on the repeat measurement.

4.Fill the Erlenmeyer flask with water (storage vessel of the same initial temperature). Make sure that you refill the water supply so that the temperatures can already equalize.

5.First measure 100 ml of the water in the measuring cylinder (exact measurement with the pipette) and fill the water into the calorimeter.

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Procedure (2/5)

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6.Place the lid with heating coil and stirring rod on the calorimeter and insert the temperature sensor through the remaining hole in the lid so that it is immersed in the water but does not touch the bottom.

7.Connect the heating coil with the connecting leads to the AC voltage output 12 V~ (power supply unit off!).

8.Wait until the temperature display remains constant.

9.Simultaneously start the measurement recording in the measure App and switch on the power supply unit. A temperature reading is recorded every second.

10. During the measurement, stir the water in the calorimeter carefully so that the heat is distributed evenly. Start stirring immediately after the start of the measurement. You can tell if you are stirring enough by the noise from the heating coil.

Procedure (3/5)

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11. Stop the measurement after 200 s and save it.

12. Switch off the power supply again!

13. Wait until the temperature display remains constant.

14. Repeat the experiment with 150 ml and 200 ml of water. Rinse the beaker in cold water and dry it out.

It may be necessary for the measurement to take longer than 200 s if the water has not yet been heated by more than 10°C compared to the start temperature.

It is best to take a screenshot of your measurement window after the 2nd and 3rd measurement in order to be able to compare the individual measurement curves better.

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Procedure (4/5)

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15. Estimate how the time of heating depends on the amount of water. You can easily read this from your multiple measurement by comparing the current measurement with the previous one.

16. From the measurement curves you can read how long it takes for a temperature increase $\Delta\theta$ of 10 °C is reached, in which you use the "Measure" function of the app in the diagram mode.

17. Carry the time $t_{\Delta\theta}$ in the log in the table of task 1.

Procedure (5/5)

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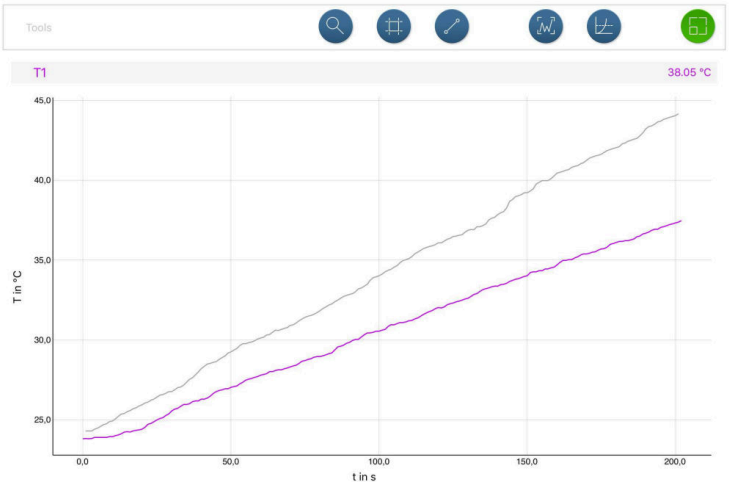
Measurement example



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Report

Task 1

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Enter your values for the time $t_{\Delta\theta}$ in this table.

Water quantity in ml	Time $t_{\Delta\theta}$ in min
100	
150	
200	

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Task 2

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Which of these statements is true, given constant heating power?

- The rate of temperature change is directly proportional to the amount of water.
- The rate of temperature change is antiproportional to the amount of water.
- The rate of temperature change falls exponentially to the amount of water.
- The rate of temperature change is independent of the amount of water.

Task 3

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Drag the words into the correct gaps

Temperature describes the average _____ of the molecules.
If there is more _____, the more energy is needed to raise the average velocities.
However, the specific _____ describes how much energy is needed to heat the water by one Kelvin. This is a _____. So the rate of temperature change falls linearly with the number of _____.

velocity
heat capacity
constant
molecules
water

Check

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Task 4

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Stirring allows the average temperature to rise more quickly as the heat is better distributed.

○ True ○ Incorrect

Check

Slide	Score / Total
Slide 21: Temperature change	0/1
Slide 22: Heat	0/5
Slide 23: Stir	0/1

Total 0 / 7

Solutions Repeat Export text

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