In general solid bodies, liquids and gases expand when heated. This only applies to water in the case of temperatures above 4°C. Water behaves in the opposite manner in a temperature range between 0°C and 4°C.

Material

1	Demo physics board	02150.00
2	Clamping holder,0-13mm,fix.magnet.	02151.07
1	Support plate on fixing magnet	02155.00
1	Holder for hand-held meters	02161.00
1	Glass beaker DURAN, short, 400 ml	36014.00
1	Glass beaker DURAN, short, 600 ml	36015.00
1	Glass rod l=200mm, d=6mm	40485.04
2	Immersion probe NiCr-Ni	13615.03
1	Temp. meter 2xNiCr-Ni, hand-held	07140.00
1	Large-scale display, digital, RS-232 port	07157.93
1	Data cable RS 232, SUB-D/USB	07157.01
	Ice cube, hammer, towel, teaspoon	

Fig. 1

Setup

- Place the support plate and the clamping holder on the table (figure 1)
- Place the hand-held meter in the holder that goes with it on the table
- Fasten the temperature sensors (immersion probes) to the handle in the clamping holders respectively, connect to the hand-held meter and initially hold it above the glass beaker
- Connect the hand-held meter with the large-scale display using the data cable

Remarks

Calibration of the temperature sensors

NiCr-Ni thermocouples can deviate from the true value when measuring absolute temperature values of up to ±2,5°C while relative temperature changes can be measured correct to 0.1 °C. It is therefore recommended that you calibrate both sensors in ice water (produced as described in the implementation) to 0°C (refer also to the operating instructions of the hand-held meter – 07140.00) prior to the experiment. The following keys < > must be pressed to do this:

- <HOLD>, Hold appears below in the display: Hold
- <Δ>, Display: Cal
- <HOLD>, Display: Set
- Set the value of the large-scale display to 0.0°C with <Δ> and <∇> (ϑ_1)
- Press <CAL>, the value for ϑ_2 appears in the large-scale display
- Set the value to 0.0°C with <Δ> and <∇>
- Press <CAL>, both temperatures are stored and the temperature meter reverts back to the standard measurement mode

Implementation

- Wrap ice cubes in a cloth and crush them with a hammer. This should result in ice fragments of different sizes.
- Fill approx. a third of the 600 ml beaker with ice
- Add 300 ml of cold water
- Stir the icy water well for about one minute with the glass rod
- Place both temperature sensors next to each other in the center of the glass beaker immediately after stirring and measure the temperature (1) (This demonstrates how well the sensors are adjusted to each other and calibrated to 0°C.)
- The 600 ml glass beaker should now contain approx. 500 ml of water with a ice layer that is approx. 2 to 3 cm thick (if necessary add or remove ice)
- Slide a thermometer down into the glass beaker so that its tip is approx. 0.5 cm above the floor
- Place the second sensor with its tip into the layer of ice
- Observe the temperatures for approx. 5 to 10 minutes (2). Do not stir! Wait for the temperature to equalize. (Wipe off the condensed water so the sensor is visible)
- Carefully remove the pieces of ice at the top, do not mix the water while doing so
- Observe the temperatures for a further 10 minutes (3)

Observation

(1) After stirring the temperature of the ice water is between 0° C and approx. 0.5°C.

(2) The temperature in the ice layer ϑ_o stays at 0°C while the temperature at the base of the glass ϑ_u slowly increases to approx. 4°C. (Table 1)

(3) The temperatures rise at the surface if no ice is present, initially at the top and also much more quickly at the top than below. (Table 2)

Table 1: with ice on the surface

$\frac{t}{\text{min}}$	$\frac{\vartheta_0}{°C}$	$\frac{\vartheta_u}{°C}$
0	0.1	0.5
5	0.1	3.2
7	0.1	3.7
10	0.1	4.0

Table 2: without ice

$\frac{t}{\text{min}}$	$\frac{\vartheta_0}{°C}$	$\frac{\vartheta_u}{°C}$
1	3.3	4.4
5	5.1	4.5
10	6.0	4.7
15	7.4	5.9

Evaluation

Ice and water are evenly mixed so that the same temperatures is present everywhere. The melting point of ice is 0°C.
If the glass is left to stand unmoved after this the ice and water will separate. Ice floats to the top, the water that is warming up sinks to the bottom, the temperature at the base slowly rises to 4°C.

If the ice is removed the temperature will initially only rise at the water surface until both temperatures are approximately equal. Then the temperature on the water surface will increase more rapidly than below. At higher temperatures the warm water is thus always on the surface (as in the case of other liquids too).

The behavior of water between a temperature of 0°C and 4°does not correspond to this general law. Reference is made to the “Anomaly of water”: Water is most dense at 4°C.

