Heating water using a parabolic trough

Task and equipment

Information for teachers

Additional information

This experiment explains the principle behind the use of a parabolic trough in the heating of liquids and the benefits it offers. A parabolic trough enables a larger share of incident energy to be utilised. It so increases the efficiency of the apparatus.

Notes on the setup and procedure

The experiment consists of two parts (heating water with and without a parabolic trough). These can also be separately worked on by groups of students. A further possibility is to divide the class into several groups, whereby each group carries out only one part of the experiment.

The temperature difference found in the two parts of the experiment is even more distinct when the sun is used for heating than when a lamp is used.
Care must be taken that the test tube is not positioned too near to the lamp, as the illumination would then be very inhomogeneous, particularly when the parabolic trough is used. This is the reason for the given distance of 10 cm.

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Task

How can liquids be effectively heated by the sun?

This experiment is intended to show the effect that the parabolic trough of the concentrated power unit has on the heating of water in a test tube by a lamp or the sun. To achieve this, the change in temperature of water in a test tube is examined.

Student's Sheet

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Equipment

Position No.	Material	Order No.	Quantity
1	Halogen lamp with reflector, 12V / 20W	05780-00	1
1	Mount for halogen lamp with reflector	05781-00	1
2	Beaker, low form, plastic, 100 ml	36011-01	1
3	Digital stop watch, 24 h, 1/100 s & 1 s	24025-00	1
4	Measuring tape, l = 2 m	09936-00	1
5	Support base, variable	02001-00	1
6	Support rod, stainless steel, l = 600 mm, d = 10 mm	02037-00	2
7	Lab thermometer,-10..+100 °C	38056-00	1
8	Concentrated solar power unit	05765-00	1
9	Boss head	02043-00	1
10	clamp, d = 16 mm, with mounting rod	05764-00	1
11	Syringe 20ml, Luer, 10 pcs	02591-03	(1)
12	Support rod, stainless steel, l = 250 mm, d = 10 mm	02031-00	1
13	PHYWE power supply DC: 0...12 V, 2 A / AC: 6 V, 12 V, 5 A	13506-93	1
Additional material			
	Water		

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Set-up and procedure

Set-up

Use the variable support base and the two support rods to set up a rail support (Figs. 1 and 2).

Fig. 1

Fig. 2

Fix the lamp in the left part of the support base and connect it to the switched-off power supply (12 V~) (Fig. 3).

Fig. 3

Fit the short rod in the right part of the support base, then fasten the boss head to the rod and slide the clamp in the boss head (Fig. 4).

Fig. 4

Fill the test tube with about 15 ml of water to bring the water level up to about 2 mm above the black paint (Fig. 5). Using the syringe allows the water volume to be easily measured.

Fig. 5

Ease the thermometer so far through the opening in the closing cap of the test tube that only the markings for temperatures higher than 15 °C are to be seen. When this is the case, screw the closing cap with thermometer on to the test tube (Fig. 6).

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Fig. 6

Experiment 1

Fit the test tube in the clamp. Position it so that the middle of the blackened part is at about the same height as the middle of the lamp (Fig. 7).

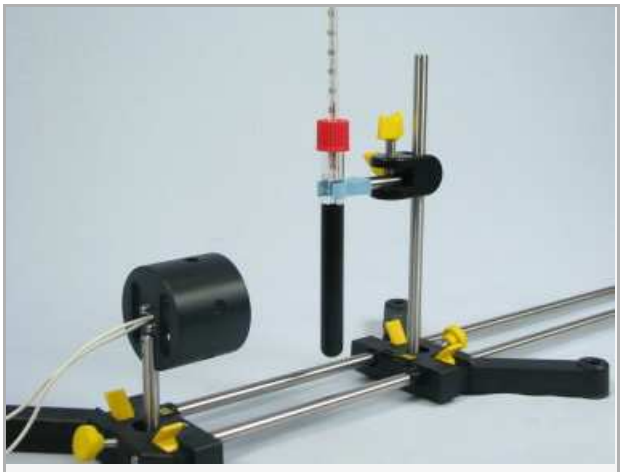

Fig. 7

Experiment 2

Fit the parabolic trough so on the test tube that both edges of the black part of the test tube protrude away from the parabolic trough to about the same extent (Fig. 8).

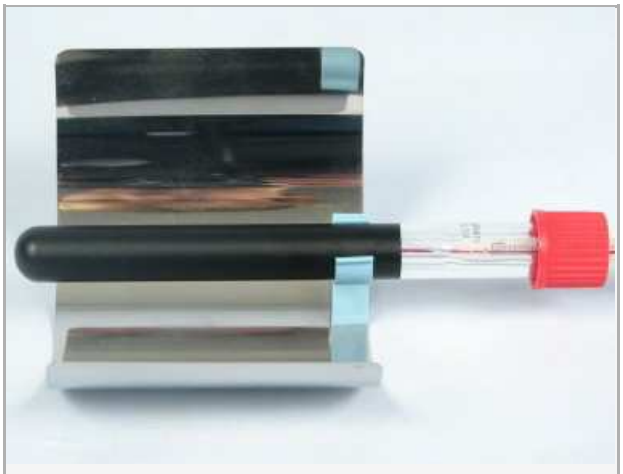

Fig. 8

Fit the test tube plus parabolic trough in the clamp. Adjust the arrangement so that the middle of the parabolic trough is at about the same height as the middle of the lamp (Fig. 9).

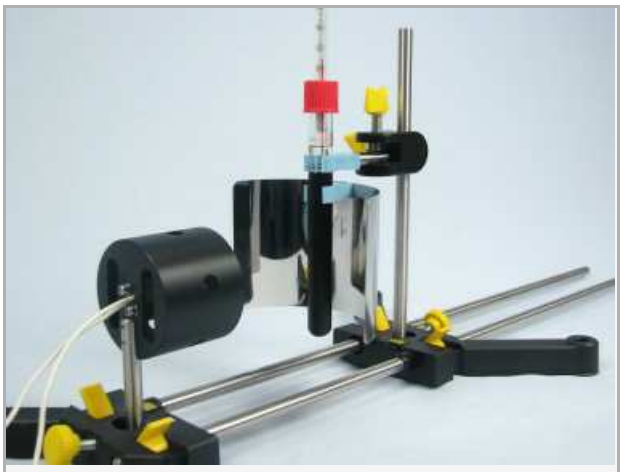

Fig. 9

Procedure

Experiment 1

Enter the temperature of the water at the start of the experiment at t = 0 min in Table 1 in the report.
Switch the lamp (power supply) on and simultaneously start the stop watch.
Note the temperature of the water in Table 1 every two minutes during the 12 minute duration of the experiment.

Experiment 2

Fill cold water into the test tube again and adjust the set-up of the test tube with reflector.
Repeat the procedure carried out in the first part of the experiment and note your observations in Table 1.

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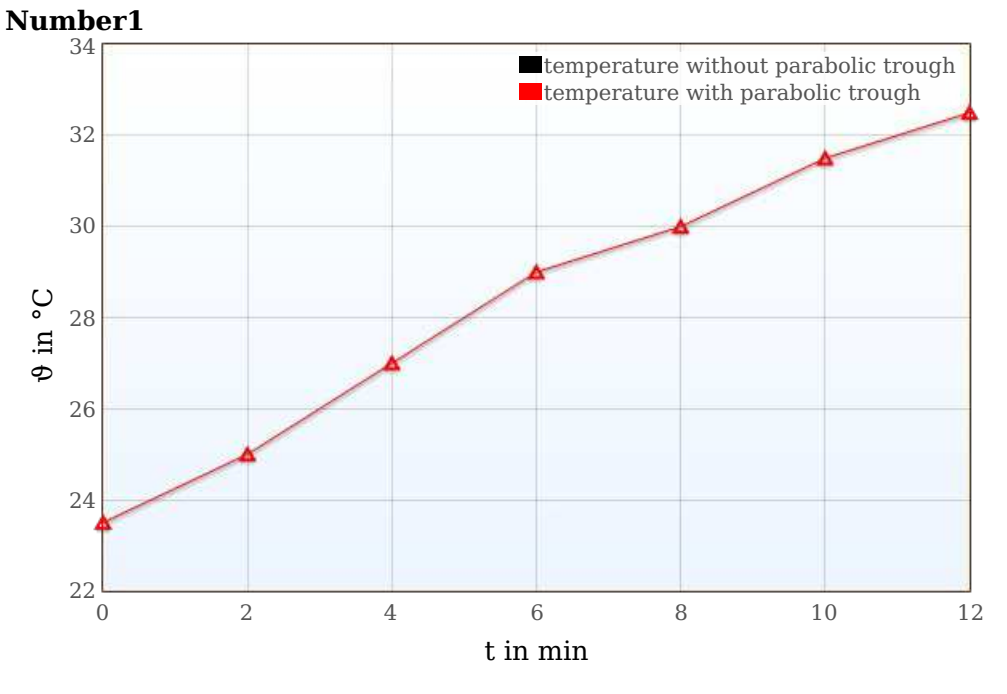
Report: Heating water using a parabolic trough

Result - Table 1

Record your measured values in the table.

	Experiment 1	Experiment 2
t in min	*ϑ* in °C	*ϑ* in °C
0	0	23,5 0
2	0	25,0 0
4	0	27,0 0
6	0	29,0 0
8	0	30,0 0
10	0	31,5 0
12	0	32,5 0



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Evaluation - Question 1

For each part of the experiment, calculate the change in temperature of the water from the difference between it at the end and at the start of the experiment. In which part of the experiment was the water most strongly heated?

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Evaluation - Question 2

Compare the course of the temperature in the two parts of the experiment and try to explain the differences in temperature. Where does the energy for the stronger heating come from?

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Evaluation - Supplementary problem 1

The courses of the two series of temperatures are plotted in the chart of Table 1. Calculate the average temperature increases per minute, explain them and describe the difference in the courses of the curves over time.

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