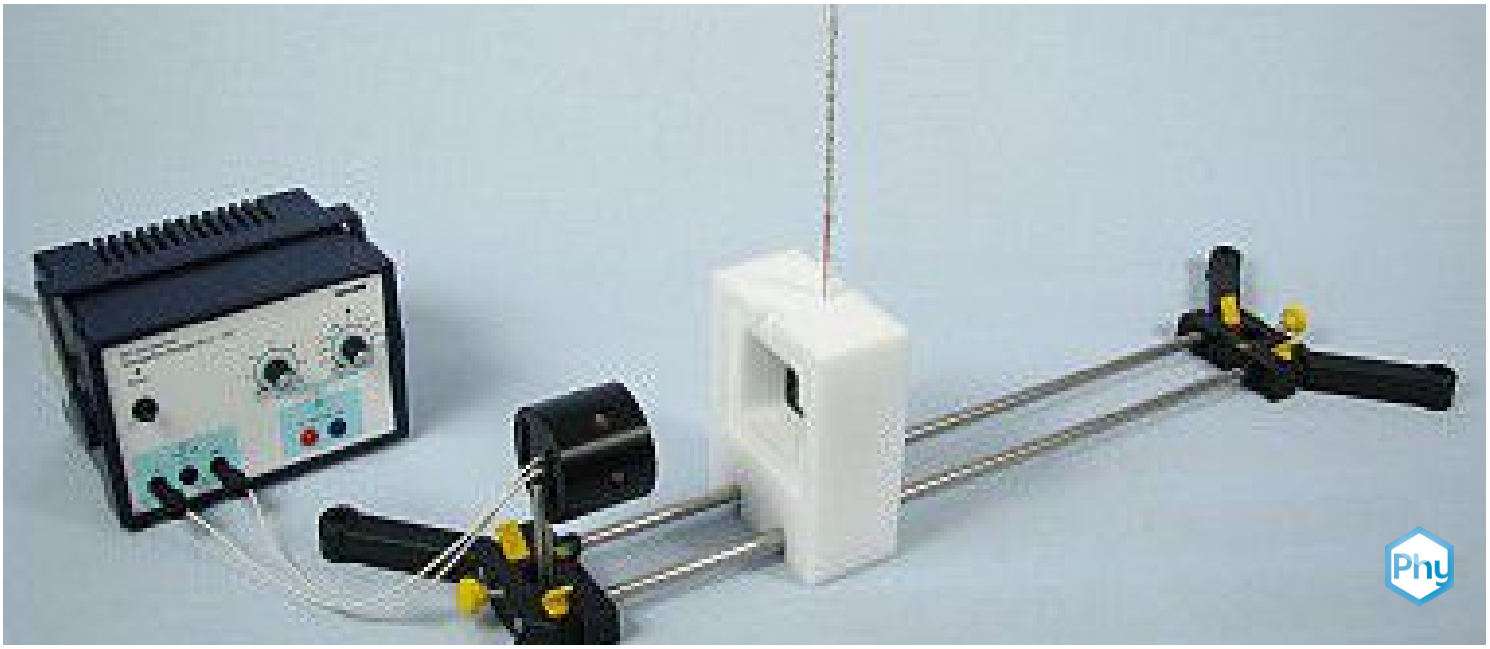
Influence of insulation on the absorption of solar energy



Physics | Energy | Renewable energies: Sun

Difficulty level	Group size	Preparation time	Execution time
easy	1	10 minutes	10 minutes

This content can also be found online at:

http://localhost:1337/c/62e8145e99933e000327069f

PHYWE
Robert-Bosch-Breite 10
37079 Göttingen
Tel.: 0551 604 - 0
Fax: 0551 604 - 107
info@phywe.de
www.phywe.de

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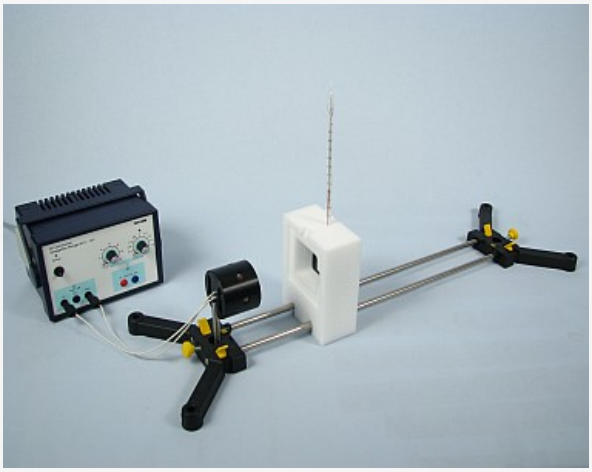
Teacher information

Application



Experimental setup

This experiment investigates the extent to which thermal insulation influences the absorption capacity of materials.

For this purpose, the temperature of an irradiated panel is compared once with and without thermal insulation and qualitative conclusions are drawn about the effects of thermal insulation on absorption behaviour.

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37079 Göttingen

Tel.: 0551 604 - 0
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info@phywe.de
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Application

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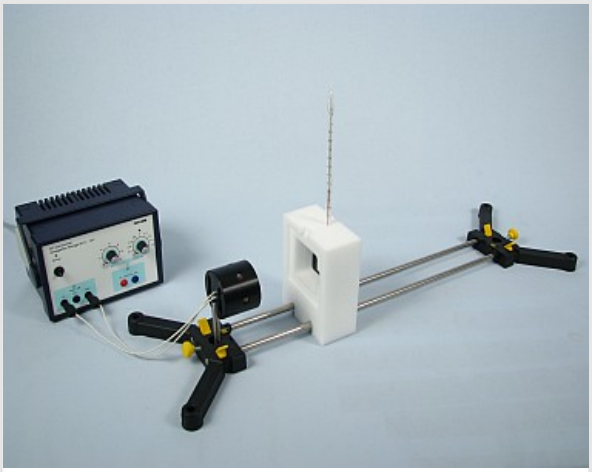

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Other teacher information (1/3)

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Prior knowledge

Students should be proficient in the use of a power supply unit.

Principle

In this experiment, the absorption behaviour of thermally insulated materials is observed and compared with that of uninsulated materials.

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info@phywe.de
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Other teacher information (2/3)

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Learning objective

Students learn about the effects of thermal insulation on the absorptive capacity of materials.

Tasks

In this experiment, compare two different set-ups and measurements with each other:

A black plate is illuminated with a 20 W lamp. For the first measurement, the plate is free-standing, for the second it is insulated at the back and sides.

Other teacher information (3/3)

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Notes on set-up and procedure

For a comparison of the two experimental set-ups, the temperatures of the black plate must be as equal as possible at the beginning of the measurements.

The plate can be cooled with tap water, but since tap water is usually colder than the room air, this should only be done for a short time.

A little patience is therefore required in any case until the initial temperature has returned.

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Safety instructions

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

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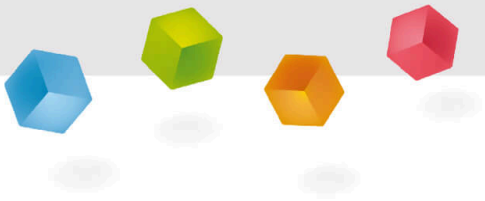

Student information

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Robert-Bosch-Breite 10
37079 Göttingen

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Motivation

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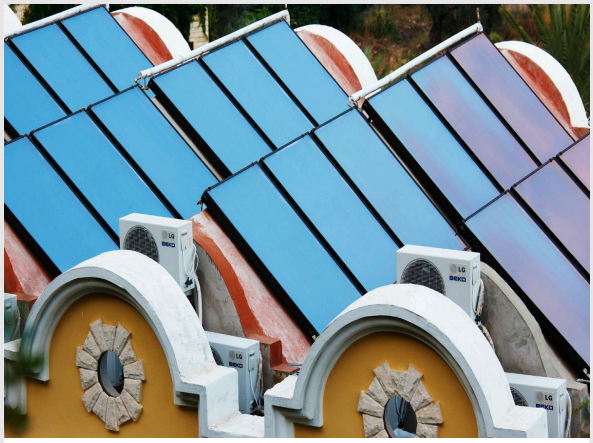

Solar panels on a roof

Unlike solar cells, solar collectors do not convert solar energy into electricity, but into heat.

The back of collector modules is insulated throughout with thermal insulation.

Thermal insulation can be found not only here, but also in houses, containers and in industry.

The following experiment is intended to convey the basics of thermal insulation and show why thermal insulation is so important today.

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Fax: 0551 604 - 107

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Equipment

Position	Material	Item No.	Quantity
1	Support base, variable	02001-00	1
2	Support rod, stainless steel, l = 600 mm, d = 10 mm	02037-00	2
3	Solar collector for student experiments	05760-00	1
4	Digital stopwatch, 24 h, 1/100 s and 1 s	24025-00	1
5	Mount for halogen lamp with reflector	05781-00	1
6	Halogen lamp with reflector, 12V / 20W	05780-00	1
7	Lab thermometer,-10..+110 °C	38056-00	1
8	Measuring tape, l = 2 m	09936-00	1
9	Slide mount for optical bench	09822-00	1
10	PHYWE Power supply, 230 V, DC: 0...12 V, 2 A / AC: 6 V, 12 V, 5 A	13506-93	1

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Set-up (1/4)

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Set-up for experiment 1

1. First screw the two-part stand rods together to form two long rods (Fig. 1).

Assemble the stand bench from the variable stand foot and the two rods (Fig. 2 and Fig. 3).

Figure 1

Figure 2

Figure 3

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Set-up (2/4)

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3. Clamp the lamp in the left part of the stand base and connect it to the power supply unit (12 V~) (Fig. 4).
The power supply unit is switched off.

4. Put the black absorber plate on the stem (Fig. 4). Attach the stem with plate in the tab and place it on the stand bench (Fig. 5).

5. Insert the thermometer into the measuring socket of the plate, move the tab until the distance between the lamp and the plate is 12 cm and align the plate parallel to the tab (Fig. 7).

Figure 4

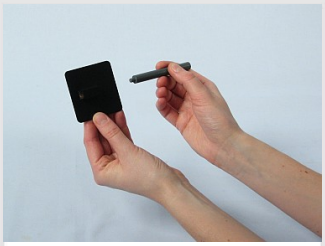

Figure 5

Figure 6

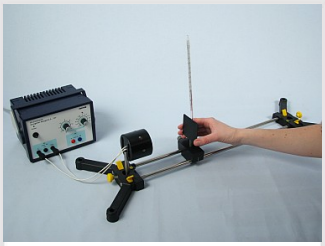

Figure 7

Set-up (3/4)

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Set-up for experiment 2

1. Hold the black plate briefly under cold water if it is still warm from the first experiment.

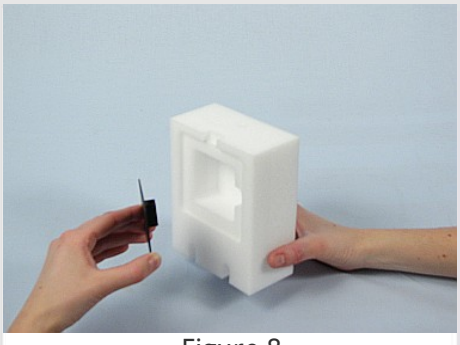

Figure 8

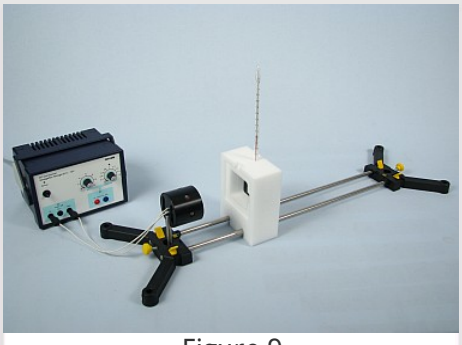

Figure 9

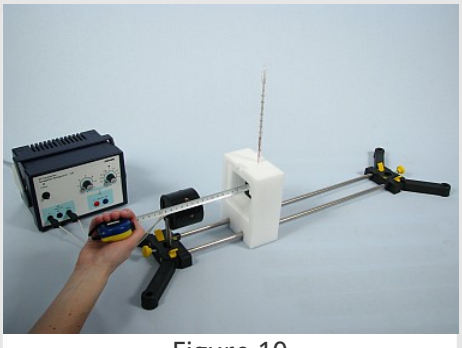

Figure 10

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37079 Göttingen

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Set-up (4/4)

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Note the illustrations on the previous slide:

2. Place the plate in the foam, making sure the measuring socket is in the correct position (Fig. 8), and push it all the way back.

3. Insert the thermometer into the measuring socket of the plate and place the foam on the stand bench (Fig. 9).

4. The distance between the plate in the foam and the lamp and should be 12 cm (Fig. 10).

Procedure

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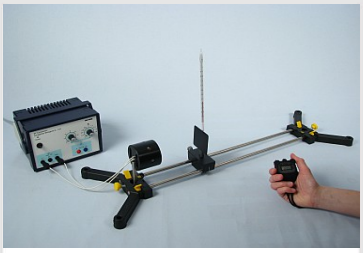

Figure 11

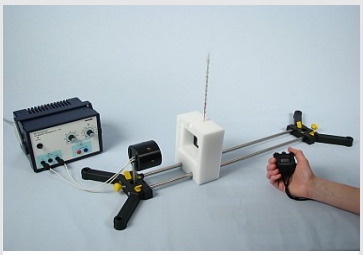

Figure 12

1. Observe the temperature before starting the measurement and wait until it stops changing.
2. Measure the initial angular temperature ϑ_1 of the black plate. Enter this under results in the report.
3. Switch on the lamp (the power supply unit) and start the stopwatch at the same time (Fig. 11).
4. After 5 minutes, switch off the power supply and measure the final temperature of the plate ϑ_2 and note them down.
5. Cool the plate if necessary and repeat the experiment with the insulation (Fig. 12).
6. Note the initial temperature ϑ_{1iso} and the final temperature ϑ_{2iso}.

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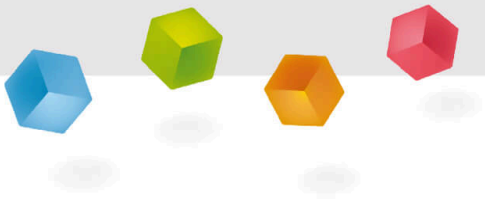

Report

Task 1

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Which of these statements is true?

- ○ The worse the thermal conductivity of the surrounding material, the greater the absorption capacity under consideration.
- ○ The absorption capacity of a material depends directly on the thermal conductivity of the surrounding material.
- ○ The absorption capacity is not influenced by the thermal conductivity of the surrounding material.

Check

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Robert-Bosch-Breite 10
37079 Göttingen

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Task 2

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Drag the words into the correct gaps

Absorptive capacity is a _____ and is therefore not directly improved by _____. However, insulation prevents the absorbed _____ from dissipating quickly. This means that higher _____ are maintained over a longer period of time. However, not because more energy is absorbed, but because less is released back into the _____.

- temperatures
- environment
- heat
- material constant
- heat insulation

Check

Task 3

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What is the unit of thermal conductivity λ?

- $\frac{W}{m \cdot K}$
- $\frac{W}{m^2}$
- $W^K \cdot m$
- $\frac{J}{(N+m) \cdot K}$

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