Absorption of thermal radiation

P1043500

Physics > Thermodynamics > Heat transfer

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

This content can also be found online at:

http://localhost:1337/c/6425daee07e83100025307a4

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

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Experimental setup

Using a test tube and a black beaker that experience heat radiation from a flame, the students learn about the absorbing property of black surfaces. This principle is used in solar thermal energy with solar collectors. The sun shines on the dark surface and thus optimally heats the heat transfer medium flowing through it.

It is also the reason why houses in areas with strong solar radiation are usually painted white. The white colour absorbs less heat energy. This prevents the house from heating up unnecessarily. In addition, this phenomenon can be observed on one's own body when one wears black clothes in summer and starts to sweat faster for this reason.

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37079 Göttingen

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Fax: 0551 604 - 107

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Other teacher information (1/3)

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Prior knowledge

Students should be familiar with a butane burner.

Principle

A test tube and a black beaker are heated by radiation. The black beaker absorbs the radiation better and heats itself and the air inside after a few minutes, because black has no reflective property. The blank test tube, on the other hand, reflects the radiation so that there is hardly any heating of the air in the cup.

Other teacher information (2/3)

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Learning objective

The students should learn that black bodies absorb heat radiation very well, whereas reflective bodies absorb it poorly in comparison.

Tasks

Investigate the heat absorption of a blank and a black surface.

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Other teacher information (3/3)

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Notes

In this experiment, the sun is replaced by a glowing flame in front of the beakers. The beakers are filled with air because water has a large heat capacity and would heat up too slowly. The flame must be in front of both beakers so that they are heated mainly by radiation and not by heat flow.

The opposite physical statement "Black surfaces radiate heat energy better than blank surfaces" can only be proven insufficiently by temperature measurement. If hot water of the same temperature is filled into both beakers/test tube, the temperature decrease is similar in both cases. The difference would have to be much greater if the heat loss were only caused by radiation. However, since the experiment does not take place in a vacuum, most of the heat is given off by heat conduction through the wall and heat dissipation to the contacting air. The proof of the different heat radiation should better be carried out in a demonstration experiment with the help of the radiation cube (Leslie) (order no. 04555-00) and radiation-sensitive thermopile (order no. 08479-00).

Safety instructions

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

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37079 Göttingen

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Student information

Motivation

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Solar thermal panels

Many houses nowadays have solar collectors installed (cf. fig.). Their function is to convert solar radiation into thermal energy. This works best when the modules have a dark coating.

You can learn more about this with the help of this experiment.

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37079 Göttingen

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Tasks

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Experimental setup

Which body can best be warmed by the sun?

Investigate the heat absorption of a blank and a black surface.

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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	1
3	Boss head	02043-00	1
4	Universal clamp	37715-01	1
5	Agitator rod	04404-10	1
6	Beaker, Borosilicate, low form, 250 ml	46054-00	1
7	Test tube,200x30 mm	36304-01	1
8	Students thermometer, -10...+110°C, l = 230 mm	38005-10	1
9	Butane burner, Labogaz 206 type	32178-00	1
10	Butane cartridge C206, without valve, 190 g	47535-01	1
11	Iron wire, d = 0.5 mm, l = 50 m	06105-00	1

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Set-up (1/3)

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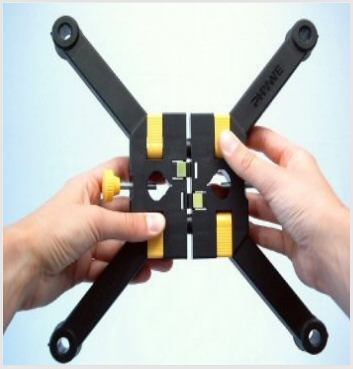
Set up the experiment according to the illustrations in order from left to right.




Set-up (2/3)

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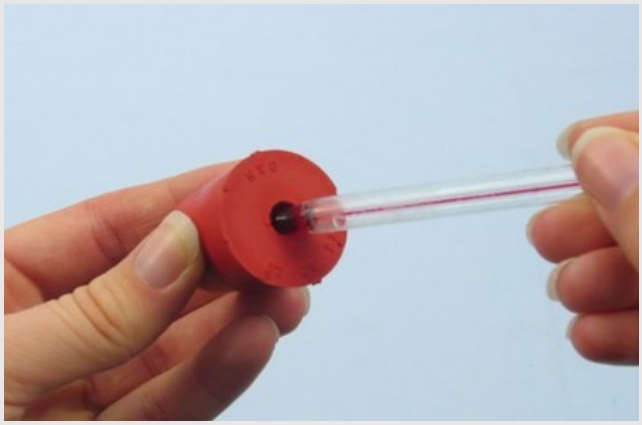
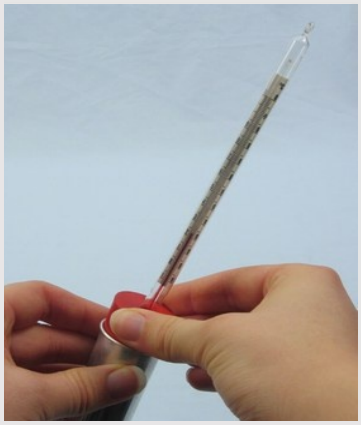

- Push both thermometers equally far into the rubber stoppers so that they stick out about 3 cm and press the rubber stoppers onto the beaker/test tube.

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Set-up (3/3)

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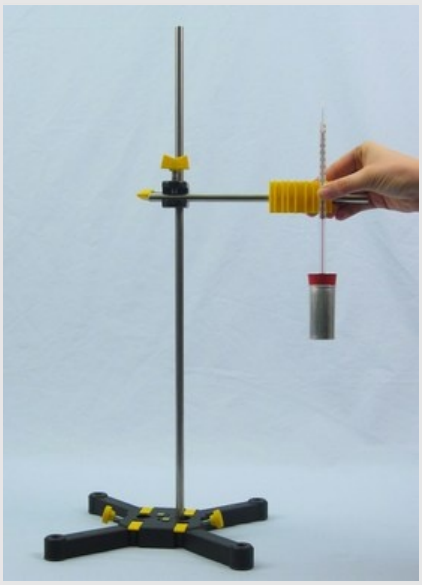
- Fix the thermometers in the glass tube holder and bring both cups to the level of the firing flame.



Procedure

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- Read off the initial temperature of both thermometers and enter it in the table (time $t = 0$).
- Place the burner with a glowing flame at a distance of approx. 5 cm in the middle in front of the two beakers.
- Start the stopwatch and read both temperatures every minute.

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Report

Task 1

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Enter the temperature of the two beakers in the table. T_1 for the blank beaker, T_2 the black one.

t in min	T_1 in °C	T_2 in °C	t in min	T_1 in °C	T_2 in °C	t in min	T_1 in °C	T_2 in °C
0			4			8		
1			5			9		
2			6			10		
3			7					

Plot the measured values in a t-T diagram.

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Task 2

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Which body absorbs heat radiation better?

- Both bodies absorb thermal radiation equally well.
- None of the bodies absorbs the heat radiation.
- The body with the black surface absorbs the heat radiation better than the one with the bare surface.
- The body with the blank surface absorbs the heat radiation better than the one with the black surface.

Task 3

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Think about whether the results of this experiment might also play a role in your life (for example, in the summer).

How else might the results of this experiment have been used (hint: picture)?

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37079 Göttingen

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Slide	Score / Total
Slide 17: Evaluation of heat radiation	**0/1**

Total 0 / 1

Solutions | Repeat | Export text

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