Conversion of mechanical energy into thermal energy

(Item No.: P1044400)

Curricular Relevance

Area of Expertise:	Education Level:	Topic:	Subtopic:	Experiment:
Physics	Age 14-16	Energy	Energy: forms, transformation and conservation	Conversion of mechanical energy into thermal energy

Difficulty	Preparation Time	Execution Time	Recommended Group Size
Intermediate	10 Minutes	10 Minutes	2 Students

Additional Requirements:

- Glycerol, 250 ml 30084-25

Experiment Variations:

Keywords:

Task and equipment

Information for teachers

Additional Information

In this experiment the potential energy of lead shot is first converted into kinetic energy by falling from a height and then into internal energy (whiting tube).

Remarks

1. The thermometer should always be insertet with the help of glycerol into the stopper with the hole.
2. The purpose of the support stand is to ensure an easily pouring of the lead shots into the tube.
3. Ensure that both stoppers are tightly seated.
4. When turning the tube, it should be held only with the fingers on each of its ends.
5. The tube must be turned at least 100 times; otherwise, the temperature differences will be too small.

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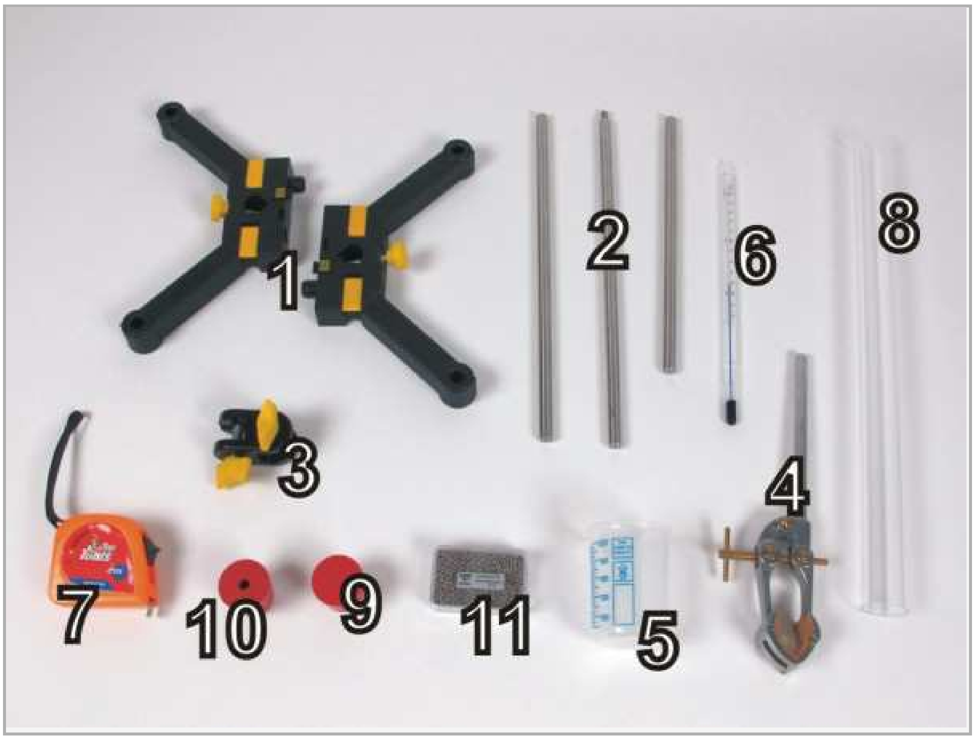
Task and equipment

Task

Can potential energy be converted into heat?

Let lead shot fall the same distance several times and then measure how much warmer it gets.

Equipment



Position No.	Material	Order No.	Quantity
1	Support base, variable	02001-00	1
2	Support rod, stainless steel, l = 250 mm, d = 10 mm	02031-00	1
3	Support rod, stainless steel, l = 600 mm, d = 10 mm	02037-00	1
4	Boss head	02043-00	1
5	Universal clamp	37715-00	1
6	Beaker, low form, plastic, 100 ml	36011-01	1
7	Lab thermometer,-10..+100 °C	38056-00	1
8	Measuring tape, l = 2 m	09936-00	1
9	Tube, plastic, d. 30mm, l. 500mm	04445-00	1
10	Rubber stopper 26/32 , without hole	39258-00	1
11	Rubber stopper 26/32, 1 hole 7 mm	39258-01	1
12	Steel pellets, d = 2 mm, 120 g	03990-00	1
Additional material:			
13	Glycerol, 250 ml	30084-25	1

Set-up and procedure

Set-up

Attention!

1. Insert the thermometer in the stopper using glycerol.
2. The thermometer must not bump into the table or other objects during the set-up or performance of the experiment.

Setup

- Set up the support stand according to the following pictures.

Fig. 1

Fig. 2

Fig. 3

Fig. 4

- Insert the thermometer in the stopper with the hole so that its tip extends about 1 cm through the stopper.
- Seal the tube in one end tightly with the stopper with thermometer.

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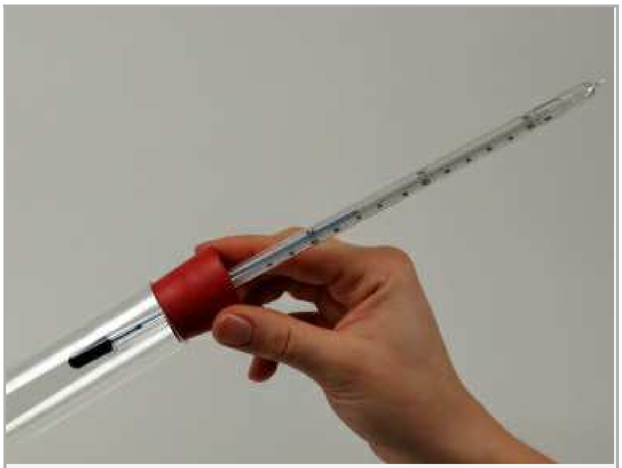

Fig. 5

- Attach the tube to the support stand with the universal clamp.

Fig. 6

- Using the beaker, pour the lead shot into the tube.

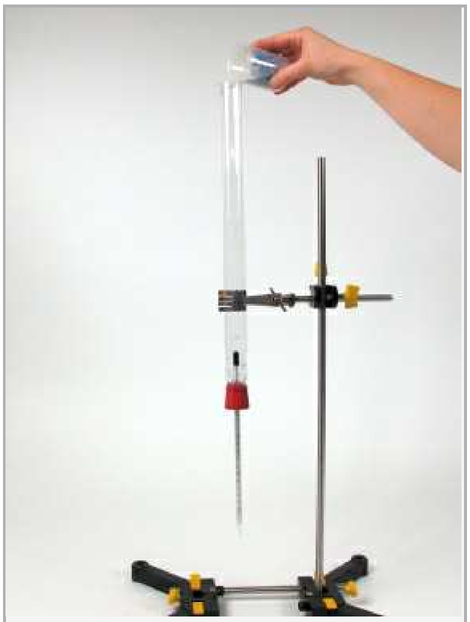

Fig. 7

Fig. 8

Procedure

1. Determine the drop distance *s* for the lead shot according to the following figure.

- Measure the distance from the upper edge of the lead shots to the upper edge of the tube (Fig. 9).

Fig. 9

- The insertion length of the upper stopper, which is inserted later (Fig. 10), must be subtracted from this distance.
- Record the drop distance *s* in the report.

2. Fall experiment

- Seal the upper end of the tube <u>tightly</u> with the stopper without hole.


Fig. 10

- Wait about 1 min until everything has reached room temperature.
- Measure and record the initial temperature ϑ_1 of the lead shot.
- Rotate the tube 100 times jerkily through 180°. The lead shot should not slide along the wall (i.e. the tube should not be slanted), but rather it should fall nearly perpendicularly all the time.


Fig. 11

- Measure the final temperature ϑ_2 of the lead shot.
- Pour the lead shot back into the beaker and wait for 1 minute, so that the lead shot can cool down.
- Repeat the experiment two more times.

Report: Conversion of mechanical energy into thermal energy

Result – Observations 1

Mass of the lead shot: m = 120 g

Drop distance: s = ... cm

Result – Table 1

Note down the initial temperature ϑ_1 and the final temperature ϑ_2 of the lead shot in the table.

Measurement	ϑ_1 in °C	ϑ_2 in °C
1.	1 ±0	1 ±0
2.	1 ±0	1 ±0
3.	1 ±0	1 ±0

Evaluation – Question 1

Calculate the temperature difference ϑ_2 - ϑ_1 for each drop and also the average value of the temperature difference.

	ϑ_2 - ϑ_1 in °C
1. Measurement	1 ±0
2. Measurement	1 ±0
3. Measurement	1 ±0
Average value	1 ±0

Evaluation – Question 2

The lead shot has a higher potential energy at the top of the tube than at the bottom. The difference is:

$E_{pot} = m \times g \times s$,

where g = 9.81 m/s^2 (acceleration of gravity). Calculate the difference in potential energy when the lead shot drops this distance 100 times.

$E_{pot} = 100 \times m \times g \times s$ = ... J.

Attention: Substitute mass in kg and the drop height in *m*! By doing so, the units for mechanical energy (1 Nm) and for heat (1 J) can be easily interconverted, i.e.: 1 Nm = 1 J.

Evaluation – Question 3

Calculate the increase in the lead shot's internal energy using the average value for $\vartheta_2 - \vartheta_1$.

$Q = c \times m \times (\vartheta_2 - \vartheta_1)$,

where c = 0,48 J/g°C (specific heat capacity of steel).

Q = ... J

Evaluation – Question 4

Calculate the energy difference, i.e. the energy which is "lost" to the surroundings:

$Q_v = E_{pot} - Q$

and the efficiency of the conversion process

$\eta = Q / E_{pot}$.

Q_v = ... J

η = ... %

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Evaluation – Question 5

Is the exact mass of the steel pellets important for the determination of the efficiency?

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Evaluation – Question 6

What sources of error are there in this experiment?

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Evaluation – Question 7

How well can potential energy (Heat) be converted into internal energy?

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