Conversion of mechanical energy into internal energy with Cobra SMARTsense

Physics	Mechanics	Forces, work, power & energy
Physics	Energy	Energy forms, conversion & conservation

Difficulty level	Group size	Preparation time	Execution time
hard	2	10 minutes	40 minutes

This content can also be found online at:

http://localhost:1337/c/6167de5b2d1cf30003518bff

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Teacher information

Application

Test setup

This experiment deals with the conversion of forms of energy; more specifically, from potential to internal energy.

For this purpose, shot pellets are dropped in a controlled manner inside a withing tube and the energy states before and after the process are recorded.

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Other teacher information (1/3)

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Previous

Students should be aware that energy can exist in different forms and that conversion between forms is possible.

Principle

In this experiment, potential energy of shot balls is converted first into kinetic energy and then into internal energy by falling down a tube (Whiting tube).

Statements are then made about the efficiency and mode of action of this conversion.

Other teacher information (2/3)

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Learning

Students learn how a conversion from potential to internal energy behaves.

Tasks

Drop shotgun pellets down a track several times and measure how much they heat up as a result.

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Other teacher information (3/3)

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Notes on structure and implementation

- Make sure that both plugs are firmly seated. When turning, only the plugs should be grasped with the hands at both ends.
- The tube must be turned over 200 times, otherwise the temperature differences become too small. However, with many more revolutions, the duration of the experiment becomes long, which leads to greater losses.
- To determine the height of fall, the measuring tape is pushed down to the shot pellets. The shot balls should not be pushed to the side.
- The mass of the shot balls can be reweighed with a balance - but the result of both the temperature increase and the efficiency is independent of the mass. It cuts out in both cases.

Safety instructions

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

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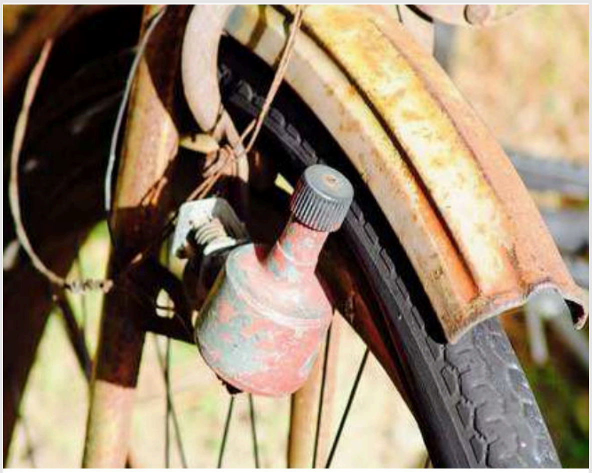
Student Information

Motivation



A bicycle dynamo

If you ride your bike at night, you need a light on your bike. Many bikes have a dynamo that converts the energy of your movement into electrical energy while you pedal.

Such energy converters occur frequently in everyday life. A car engine converts chemical energy into electrical energy, which in turn is converted into kinetic energy.

Now the question arises whether other forms of energy can also be converted into each other. In this experiment, you will investigate whether mechanical energy can be converted into internal energy, i.e. heat.

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Tasks (1/2)

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For measurement with the **Cobra SMARTsense sensors** the **PHYWE measureAPP** is required. The app can be downloaded free of charge from the relevant app store (see below for QR codes). Before starting the app, please check that on your device (smartphone, tablet, desktop PC) **Bluetooth** is **activated**.

iOS

Android

Windows

Tasks (2/2)

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The experimental setup

Can potential energy be converted into heat?

Drop shotgun pellets down a track several times and measure how much they heat up as a result.

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Equipment

Position	Material	Item No.	Quantity
1	Cobra SMARTsense - Temperature, - 40 ... 120 °C (Bluetooth)	12903-00	1
2	Support base, variable	02001-00	1
3	Support rod, stainless steel, l = 250 mm, d = 10 mm	02031-00	1
4	Support rod, stainless steel, l = 600 mm, d = 10 mm	02037-00	1
5	Boss head	02043-00	1
6	Universal clamp	37715-01	1
7	Tube, plastic, d. 30mm, l. 500mm	04446-00	1
8	Rubber stopper 26/32 , without hole	39258-00	1
9	Rubber stopper 26/32, 1 hole 7 mm	39258-01	1
10	Steel pellets, d = 2 mm, 120 g	03990-00	1
11	Beaker, 100 ml, plastic (PP)	36011-01	1
12	Measuring tape, l = 2 m	09936-00	1
13	measureAPP - the free measurement software for all devices and operating systems	14581-61	1

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Set-up (1/3)

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Figure 1

Attention:

- The tube with the thermometer must be freely rotatable. The sensor must not hit against a table or rod.
- The universal clamp in the sleeve should only be screwed on lightly.

The assembly is carried out according to Fig. 1.

1. Set up the tripod. Make sure that the big rod is screwed really tight.

Set-up (2/3)

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Figure 2

2. Insert the temperature sensor through the hole in the plug so that it sticks out about 1.5 cm.

To ensure that the sensor is really tight and that the plug can seal the tube completely, it is necessary to wrap it with adhesive tape and adjust its thickness to the bore (see Fig. 2).

3. Close the tube tightly with the plug with the temperature sensor.

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Set-up (3/3)

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4. Attach the tube to the tripod.

5. Using the beaker, carefully and slowly pour the buckshot into the tube. If you go too fast, the bullets like to jump in all directions.

Procedure (1/6)

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1. determine the height of fall s of the buckshot:

1. Carefully insert the tape measure into the tube until it meets the shot balls at the bottom.

2. From the value at the upper pipe edge, the part of the upper plug that protrudes into the pipe must be subtracted.

3. Note the height of the fall s.

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Procedure (1/6)

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Second drop test:

1. Turn on your Cobra SMARTsense temperature sensor. Open the measureAPP app and select the temperature sensor.

2. Set the sampling rate to 1 Hz.

3. Close the top of the tube tightly with the plug without drilling.

4. Start the measured value recording in measureApp, a temperature measured value is then recorded every second.

5. Wait approx. 100 s until the temperature display has stabilised - temperature sensor at the bottom in contact with the balls.

Procedure (2/6)

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6. Turn the tube 200 times by 180° (back and forth). Try to hold the pipe only by the stoppers. The pellets should not slide along the wall, but fall down as freely as possible.

It is helpful if your partner holds the tripod and stabilizes it a bit.

7. Wait another 100 s until the measured value has stabilized, temperature sensor down in contact with the shot.

8. Finish the measurement and save it.

9. Pour the shot back into the beaker to cool again.

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Procedure (3/6)

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12. While the balls are cooling down, you can start evaluating them.

13. Repeat the experiment in the same way two more times.

Procedure (4/6)

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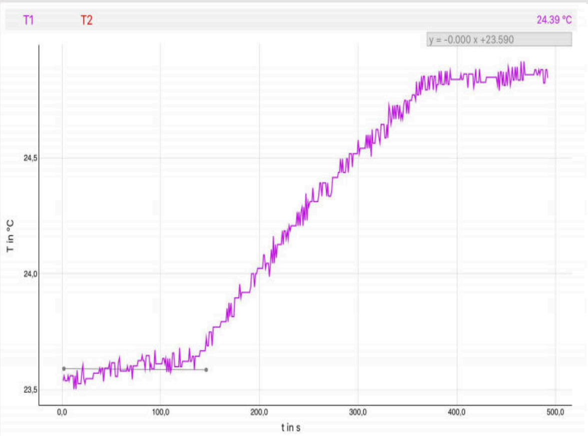

Figure 3

3. evaluation of the data

1. Select the regression tool and use it to determine the initial temperature θ_1 of the shot balls as well as the final temperature of the shot balls after 200 times of falling down, in which you put a straight line of the gradient 0 as an average value through the constant ranges (see fig. 3). θ_2 is the temperature maximum that occurs at the end of the measurement.

Record your results in Table 1 in the log.

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Procedure (5/6)

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2. Calculate the temperature difference for all three measurements $\Delta\theta = \theta_2 - \theta_1$ and enter this in Table 1 as well.

3. Enter the drop height in Table 2.

4. The shot balls have a higher potential energy at the upper end of the tube than at the lower end.

The difference is: $\Delta E\mathrm{pot} = m_{\mathrm{Stahl}} \cdot g \cdot s$ at the acceleration due to gravity $g = 9,81\,\frac{m}{s^2}$.

If the balls have been lifted 200 times this distance, then the mechanical energy has been supplied to them: $E_{\mathrm{mech}} = 200 \cdot m_{\mathrm{Stahl}} \cdot g \cdot s$(1)

Calculate E_{mech} according to (1). Complete table 3.

Procedure (6/6)

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5. Calculate in each case the change in the internal energy of the shot pellets $\Delta Q = c_{\mathrm{Stahl}} \cdot m_{\mathrm{Stahl}} \cdot \Delta\theta$ with the specific heat capacity of steel $c_{\mathrm{Stahl}} = 0,45$ in J/(g °C). Enter the values in Table 3.

6. Calculate the energy in each case Q_{V} which was dissipated as a loss to the environment and the efficiency of the conversion process η. The following applies

$$Q_{\mathrm{V}} = E_{\mathrm{mech}} - \Delta Q \text{ und } \eta = \frac{\Delta Q}{E_{\mathrm{mech}}}$$

Add Table 3 to the log.

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Report

Task 1

Complete this Table 1 following the steps from the implementation.

	θ_1 in °C	θ_2 in °C	$\Delta\theta = \theta_2 - \theta_1$ in °C
Measureme			
Measureme			
Measureme			

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Task 2

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Fill in this table 2.

Drop height s in mm	
Shot mass m_{Stahl} in g	

Task 3

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Fill in this Table 3 using the formulas defined in the implementation.

	ΔQ in J	Q_{V} in J	η in %
1.			
2.			
3.			

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Task 3

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Which energy conversion primarily took place in this experiment?

- Inner energy ⇒ Potential energy
- Potential energy ⇒ Electrical energy
- Potential energy ⇒ Kinetic energy and back
- Potential energy ⇒ Inner energy

Task 4

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By what physical process does the shot heat up?

- Diffusion
- Evaporation
- Condensation
- Friction

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Task 5

Enter the value for E_{mech} with unit, which you calculated in the execution:

Task 6

In which direction does the frictional force of the buckshot act?

- The frictional force acts perpendicular to the direction of fall of the shot pellets away from the tube.
- The frictional force acts against the direction of fall of the shot pellets.
- The frictional force acts in the direction of fall of the shot pellets.
- The frictional force acts perpendicular to the direction of fall of the shot pellets into the tube.

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Slide	Score / Total
Slide 26: Heat quantity	0/1
Slide 27: Friction	0/1
Slide 29: Frictional force	0/1

Total 0/3

Solutions Repeat Export text

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