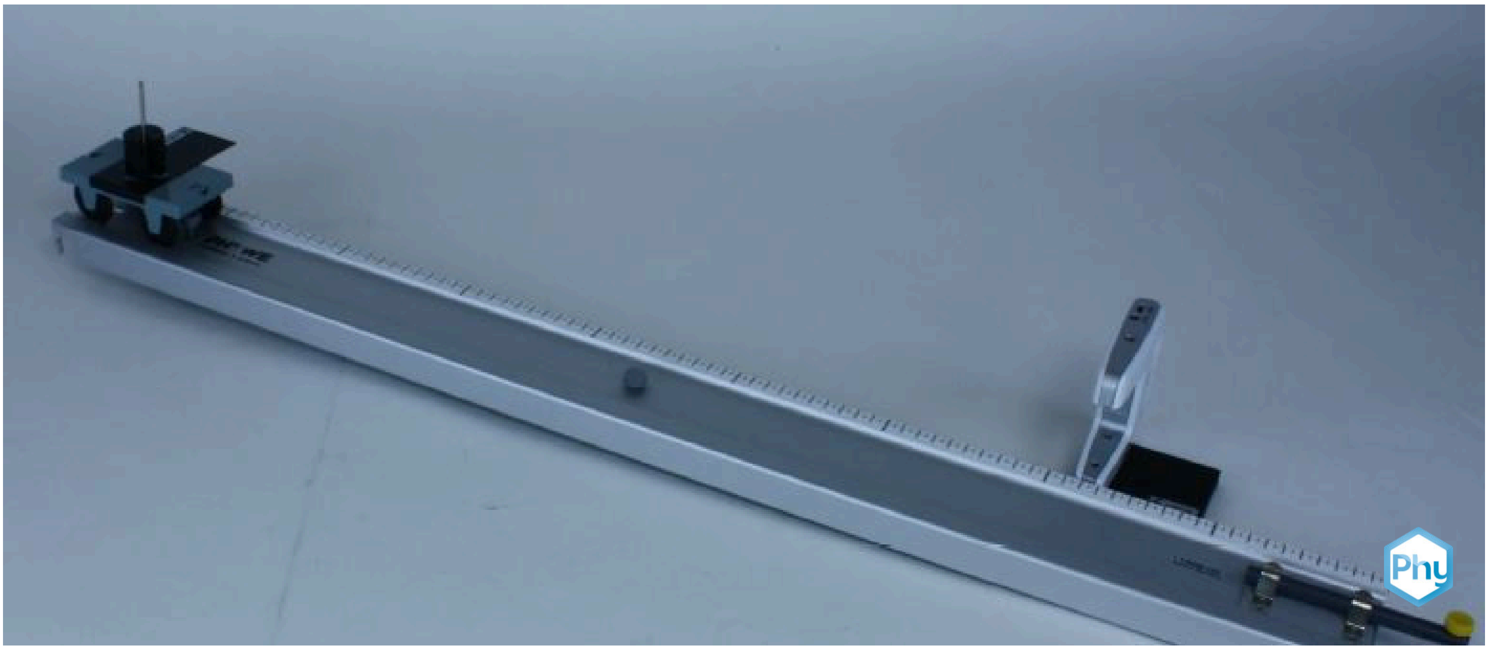
Potential and kinetic energy with Cobra SMARTsense



Physics | Mechanics | Dynamics & Motion

Difficulty level	Group size	Preparation time	Execution time
medium	2	10 minutes	10 minutes

This content can also be found online at:

http://localhost:1337/c/5f31dc2dab3ef70003158242

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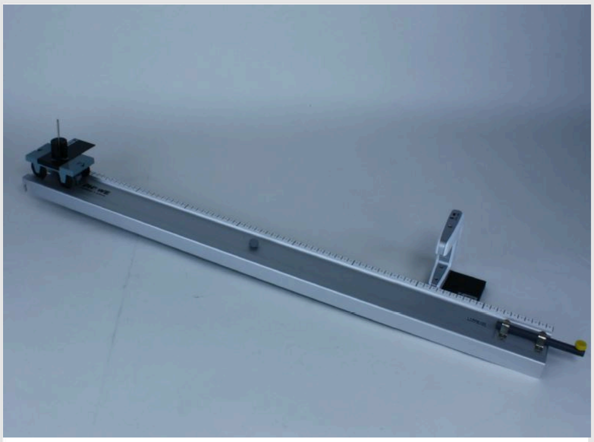
Teacher information

Application



Experiment set-up

Energy is one of the most important physical quantities. It determines our everyday life in many places: We have to take in energy in the form of food and we need energy to drive. All electrical appliances convert energy, we heat our houses with energy and much more.

An example of energy conversion is the use of potential energy from water in a reservoir, which is converted into kinetic energy. This kinetic energy of the water shooting down the pipes finally drives the turbines and generators, which then convert the kinetic energy into electrical energy.

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Other teacher information (1/2)

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Prior knowledge

Students should know the difference between potential and kinetic energy and be able to calculate velocities from distance and time. The students should be able to determine the slope of an approximately linear path.

Scientific principle

The law of conservation of energy states that the total energy of a closed system is always the same and is only converted between different forms of energy.

$$\Sigma E_i = E_{pot} + E_{kin} = m \cdot g \cdot h + \frac{1}{2} \cdot m \cdot v^2$$

Other teacher information (2/2)

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Learning objective

In this experiment the students should understand the conversion of potential energy into kinetic energy and thereby recognize the core statement of the law of conservation of energy. The students are to understand the proportionality of kinetic energy to the square of the velocity $E_{kin} \propto v^2$ and to determine the proportionality factor $m/2$.

Tasks

1. The students let a measuring cart cover a distance s and measure the shading time t. With the help of t and the width of the shading diaphragm $b = 5\,cm$ then determine the speed v.
2. Then they calculate from the acceleration distance s the potential energy E_{pot} and carry them over v^2 on. The gradient corresponds to the factor $k$whose dimension is to be determined.

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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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Motivation

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Hoover Dam in Arizona

Energy is one of the most important physical quantities. It determines our everyday life in many places: We have to take in energy in the form of food and we need energy to drive. All electrical appliances convert energy, we heat our houses with energy and much more.

An example of energy conversion is the use of potential energy from water in a reservoir, which is converted into kinetic energy. This kinetic energy of the water shooting down the pipes finally drives the turbines and generators, which then convert the kinetic energy into electrical energy. In this experiment, the potential energy of a measuring cart is converted into kinetic energy.

Tasks

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1. Let the measuring cart accelerate over the track by its weight force. Then determine the speed v of the measuring cart in the rear section of the track by setting the shadowing times t a light barrier for different routes s measures.

2. Calculate from the acceleration distances s and the resulting height difference h the weight and the mass m the converted potential energy and relate it to the squared velocity v^2.

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Equipment

Position	Material	Item No.	Quantity
1	Cobra SMARTsense - Photogate, 0 ... ∞ s, two pieces (Bluetooth)	12909-00	1
2	Track, l 900 mm	11606-00	1
3	Meter scale, demo. l=500mm, self adhesive	03005-00	1
4	Cart for measurements and experiments	11060-00	1
5	Shutter plate for cart	11060-10	1
6	Holding pin	03949-00	1
7	Adapter plate for Light barrier compact	11207-22	1
8	Silk thread, l = 200 m	02412-00	1
9	Weight holder, silver bronze, 1 g	02407-00	1
10	Slotted weight, black, 50 g	02206-01	3
11	Slotted weight, black, 10 g	02205-01	4
12	Pulley,movable,dia.40mm,w.hook	03970-00	1
13	Rod for pulley	02263-00	1
14	measureAPP - the free measurement software for all devices and operating systems	14581-61	1

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Set-up (1/6)

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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

Set-up (2/6)

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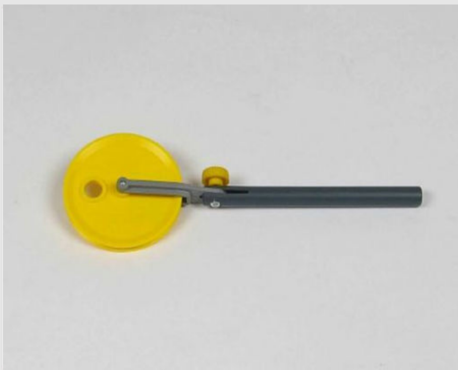
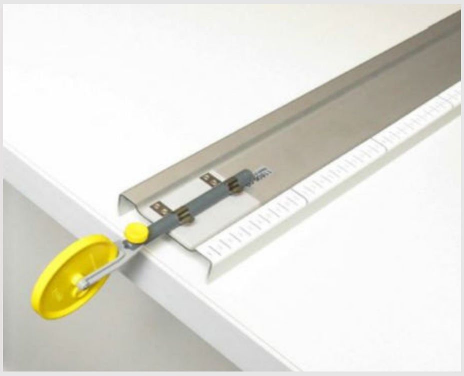
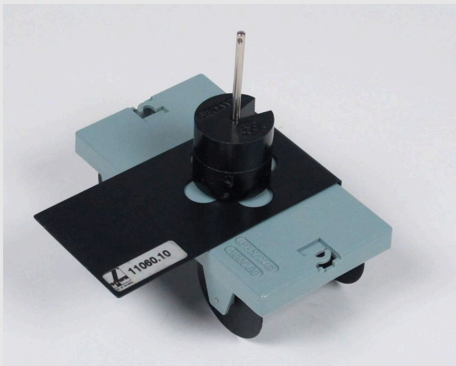
Connect the pulley to the handle and then carefully slide the handle under the retaining clips at the end of the track. To do this, lightly lift the holding clamps with your fingers. Position the track at the end of the table so that the pulley can rotate freely.

Take the measuring carriage, attach to it the holding bolt, the shading screen and two 50 g masses.







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Set-up (3/6)

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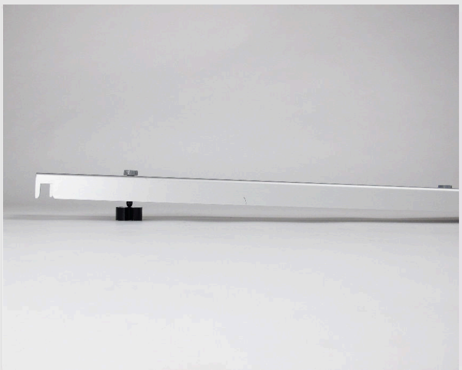
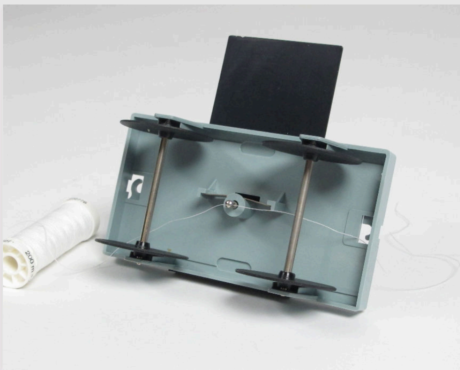
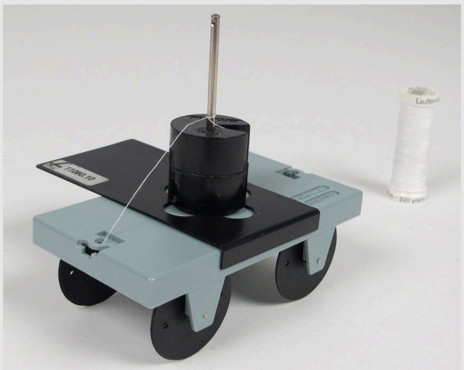
Tilt the track so that the slightly pushed car continues to roll at as constant a speed as possible. To do this, place the set screw at the other end of the track on slotted weights and use it to adjust the incline. Then guide the end of the sewing silk through the hole of the holding bolt on the bottom of the carriage, guide it through the back of the carriage to the top of the carriage and knot it to the holding bolt.

Set-up (4/6)

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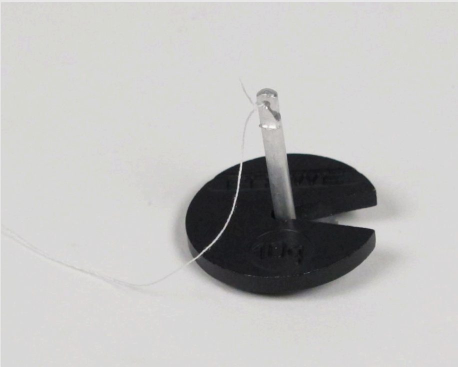
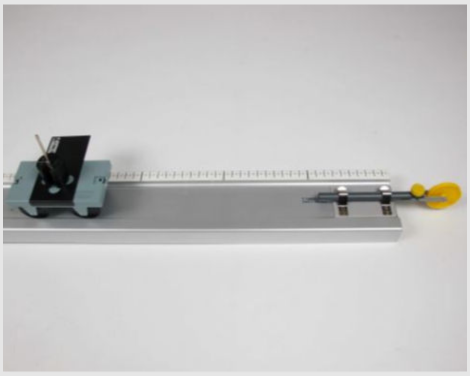
Knot the other end of the thread to the 1-g weight plate and weigh it down with a 10-g slotted weight. Choose the length of thread so that the weight plate touches the floor when the car is about 15 cm from the end of the road. Now place the thread over the roller. The thread should now run above the axle of the trolley and parallel to the roadway.

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Set-up (5/6)

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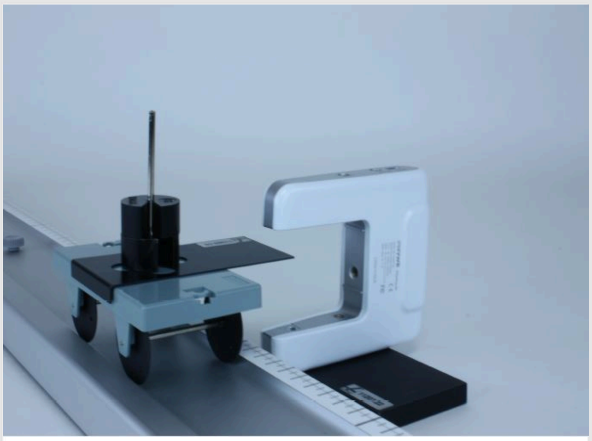

Connect adapter plates with the photogate

Connect the adapter plate to the photogate A in such a way that it can be placed easily next to the track and the screen on the cart can pass through the photogate without bumping into it.

Set-up (6/6)

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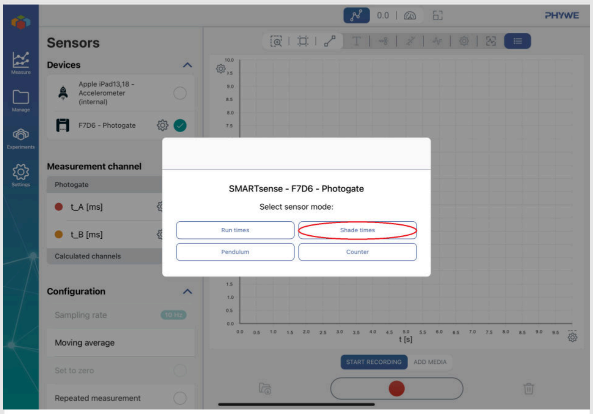

Selection of the measuring mode in the measureAPP

Switch on the light barrier and connect it to measureAPP. To do this, select the photogate in the "Sensor" menu.

In the menu that appears, select the option "Shading time". This measures the shading time of the light barrier, from which the speed of the car can be determined.

Set the digital measured value display last.

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Procedure (1/2)

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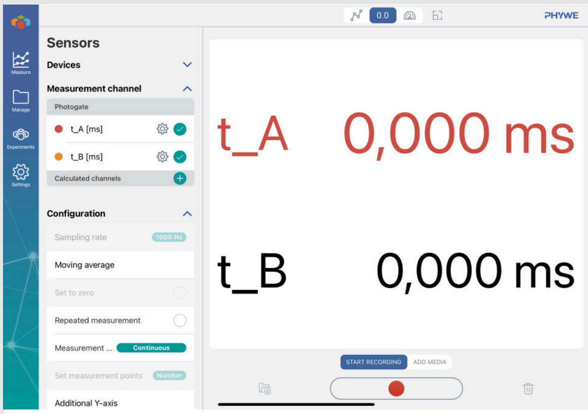

Digital measured value display in measureAPP

- Position the cart on the track at the point where the weight plate just touches the floor when the thread is tensioned.
- Place the light barrier on the track so that it is interrupted by the screen as soon as possible after the weight has reached the ground.
- Now push the cart from this position around the track $s = 10\,cm$ uphill. The weight is increased by the same distance s lifted. So now the track s equal to the height h of the weight above the floor.

Procedure (2/2)

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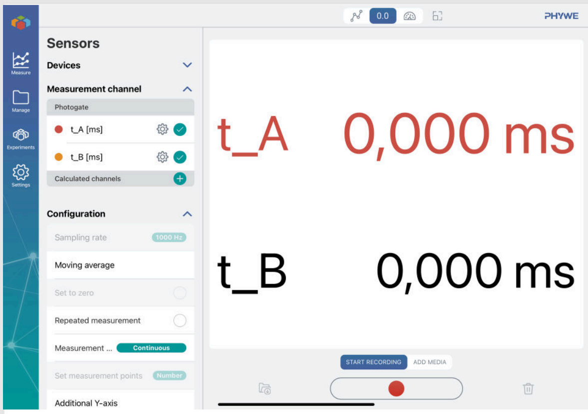

Digital measured value display in measureAPP

- Check whether the yarn really runs over the deflection roller and that it can rotate freely.
- Start the measurement and release the car without hitting it and catch it behind the photogate.
- Finish the measurement and read the shadowing time t off.
- Repeat the measurement and increase the distance $s$by which you lift the weight with the cart, in 10-cm increments up to $s = 60\,cm$.
- Note all resulting measured values in Table 1 in the Report.

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Report

Table 1

Enter the measured shading times t in the table.

Calculate from the shading times t and the aperture width $b = 5\,cm$ the final speeds $v = b/t$ of the car. Enter the values in the second column.

Calculate the potential energy $E_{pot} = m \cdot g \cdot h$ with: $g = 9,81\,m/s^2$ and the square of the speeds reached v^2.

$h\ [cm]$	$t\,[s]$	$v\,[cm/s]$	$E_{pot}\,[Nm]$	$v^2\,[m^2/s^2]$
10				
20				
30				
40				
50				
60				

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Task 1

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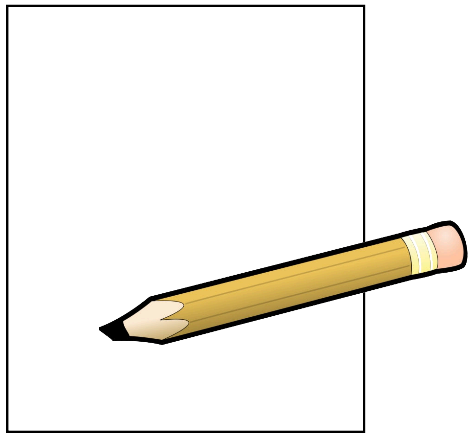
Now take a sheet of paper and create a diagram on it. In this diagram you represent the potential energy E_{pot} (y-axis) as a function of the square of the speed v^2 (x-axis).



Task 2

PHYWE

What conclusions can be drawn from the curve, taking into account that the potential energy has been converted into kinetic energy and thus v^2 represents the kinetic energy?

- [ ] Since the curve goes through the origin, the car has no kinetic energy when it is not moving.
- [ ] The linearity shows that the kinetic energy E_{kin} is proportional to the square of the speed $E_{kin} \sim v^2$

Check

Task 3

PHYWE

Determine the value of the total accelerated mass $m_{ges} = m_W + m_G$ (m_W: Car mass; m_G: mass of the towing weight).

Note: The empty car has a mass of $42\ g$the retaining bolt has a mass of $7\ g$ and the shading screen has a mass $10\ g$. Enter the resulting value.

m_{ges} = [ ]

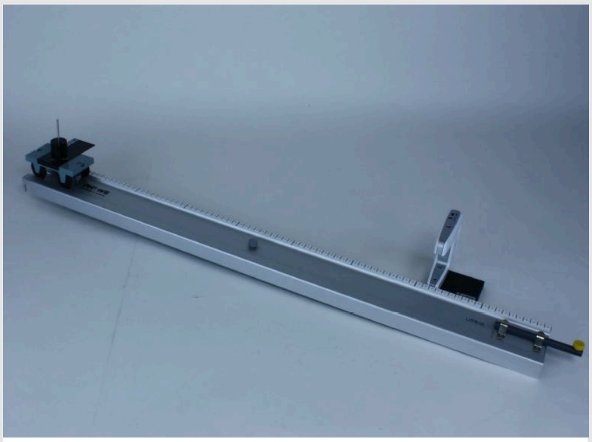
Determine the gradient k of the curve from the diagram (E_{pot} against v^2) and enter the numerical value.

Think about the physical dimension of the gradient and note it down as well.

k = [ ] [ ]

Task 4

PHYWE



Experiment set-up

Which unit has the gradient k?

- ○ m/s
- ○ kg/m^3
- ○ kg
- ○ Ncm

Check

Task 5

PHYWE

Compare the value of the slope with the total accelerated mass.

The accelerated mass...

- ...is about half the value of the slope.
- ...bears no discernible relation to the value of the slope.
- ...is about twice the value of the slope.
- ...is about the same as the value of the slope.

Check

Task 6

PHYWE

Assume that the kinetic energy is $E_{kin} = \frac{1}{2} \cdot m \cdot v^2$ and this is equal to the potential energy $E_{pot} = m \cdot g \cdot h$.

Using the experimental data, find out the values of the accelerated mass m_{exp} for the equation $\frac{1}{2} \cdot m_{exp} \cdot v^2 = E_{pot}$ to m_{exp} get solved.

Calculate with it m_{exp} as an example for some measurement series.

If the experiment allows the assumed law $E_{kin} = \frac{1}{2} \cdot m \cdot v^2$ confirm?

- No, the experiment did not confirm the equation.
- Yes, the experiment confirmed the equation.

Check

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Task 6

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Assume that the kinetic energy is $E_{kin} = \frac{1}{2} \cdot m \cdot v^2$ and this is equal to the potential energy $E_{pot} = m \cdot g \cdot h$.

Using the experimental data, find out the values of the accelerated mass m_{exp} for the equation $\frac{1}{2} \cdot m_{exp} \cdot v^2 = E_{pot}$ to m_{exp} get solved.

Calculate with it m_{exp} as an example for some measurement series.

If the experiment allows the assumed law $E_{kin} = \frac{1}{2} \cdot m \cdot v^2$ confirm?

- No, the experiment did not confirm the equation.
- Yes, the experiment confirmed the equation.

Check