Potential and kinetic energy with the 2-1 timer

Physics | Mechanics | Energy conservation & impulse

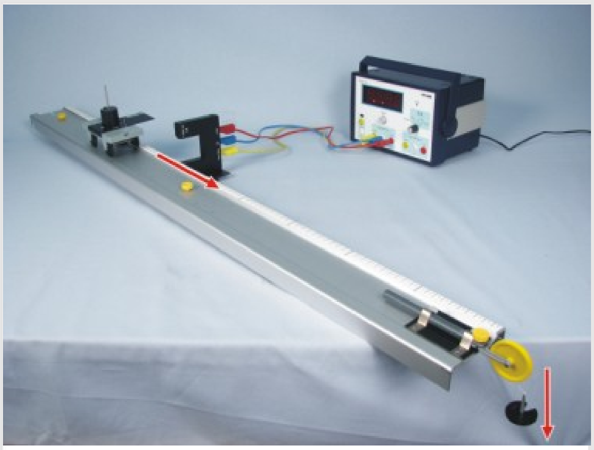
Difficulty level	Group size	Preparation time	Execution time
hard	2	10 minutes	20 minutes

This content can also be found online at:

http://localhost:1337/c/5fdbb8c15098f00003f1edee

Teacher information

Application



Experiment set-up

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

An example of energy conversion is the use of potential energy of water in a reservoir, which is converted into kinetic energy. This kinetic energy of the water shooting down through the tubes eventually 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 velocity from displacement and time. Students should be able to independently determine the slope of an approximate linear graph.

Scientific principle

The law of conservation of energy states that the total energy of a closed system is always the same and is merely 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)

PHYWE

Learning objective

In this experiment, students will learn about the conversion of potential energy to kinetic energy, recognizing the key statement of the law of conservation of energy. The students should recognize the proportionality of kinetic energy to the square of speed $E_{kin} \propto v^2$ and determine the proportionality factor to $m/2$.

Tasks

1. The students let a car drive a distance s and measure the shading time t. With the help of t and the width of the shading screen $b = 5\,cm$ they 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. The slope corresponds to the factor k 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

Hoover Dam, Arizona

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

An example of energy conversion is the use of potential energy of water in a reservoir, which is converted into kinetic energy. This kinetic energy of the water shooting down through the tubes eventually drives the turbines and generators, which then convert the kinetic energy into electrical energy. In this experiment, the potential energy of a car is converted into kinetic energy.

Tasks

1. Let the car travel over the track accelerated by its weight. Then determine the speed v of the car in the rear section of the track by t a light barrier for different distances s measures.
2. Calculate from the acceleration distances s and the resulting height difference h the weight as well as the mass m the converted potential energy and relate this to the squared velocity v^2.

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Equipment

Position	Material	Item No.	Quantity
1	Cart for measurements and experiments	11060-00	1
2	Shutter plate for cart	11060-10	1
3	Holding pin	03949-00	1
4	Silk thread, l = 200 m	02412-00	1
5	Weight holder, silver bronze, 1 g	02407-00	1
6	Slotted weight, blank, 1 g	03916-00	4
7	Slotted weight, black, 10 g	02205-01	4
8	Slotted weight, black, 50 g	02206-01	3
9	Pulley,movable,dia.40mm,w.hook	03970-00	1
10	Rod for pulley	02263-00	1
11	PHYWE Timer 2-1	13607-99	1
12	Light barrier, compact	11207-20	1
13	Adapter plate for Light barrier compact	11207-22	1
14	Connecting cord, 32 A, 1000 mm, red	07363-01	1
15	Connecting cord, 32 A, 1000 mm, yellow	07363-02	1
16	Connecting cord, 32 A, 1000 mm, blue	07363-04	1
17	Track, l 900 mm	11606-00	1

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Set-up (1/5)

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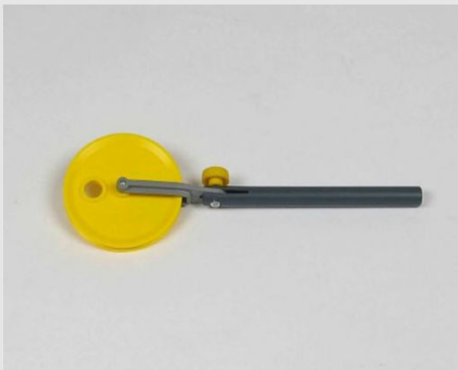
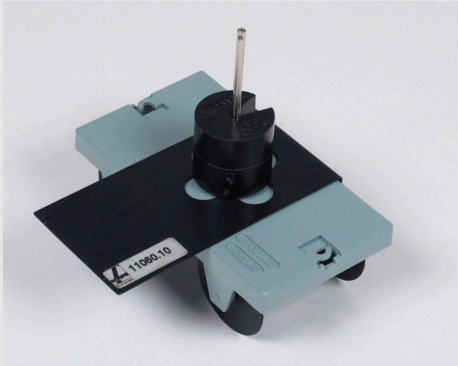
Connect the pulley to the handle and then carefully slide the handle under the brackets at the end of the track. To do this, lift the retaining clips slightly with your fingers. Position the track at the end of the table so that the pulley can rotate freely.

Take the car attach the holding pin to it, the shading screen and two 50 g masses.





Set-up (2/5)

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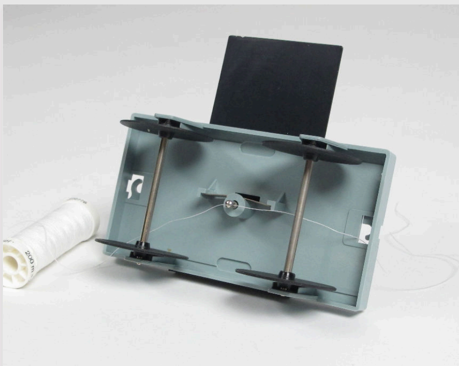
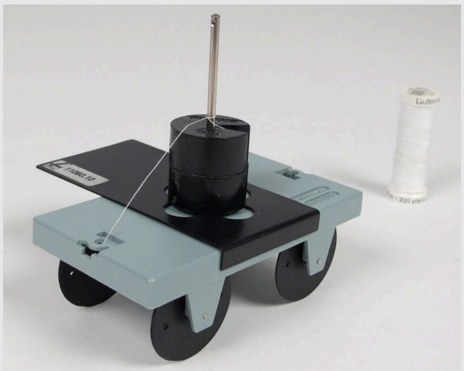
Tilt the track so that the lightly pushed car rolls on at as constant a speed as possible. To do this, set the set screw at the other end of the track to slot weights and use it to adjust the incline. Then feed the end of the sewing silk through the hole of the holding pin at the bottom of the car, feed it through to the back of the top of the car and knot it to the holding pin.





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Set-up (3/5)

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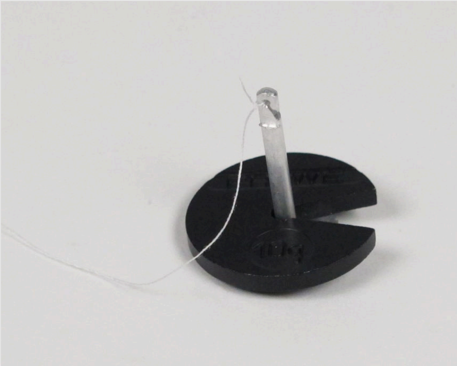
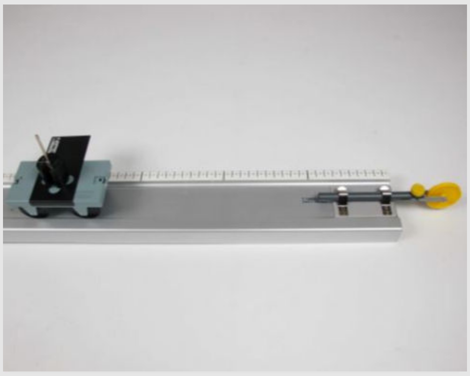
Tie the other end of the thread to the 1 g weight plate and weigh it down with a 10 g slotted weight. Choose the length of the thread so that the weight plate comes to rest on the floor when the car is about 15 cm from the end of the track. Now place the thread over the pulley. The thread should now run above the axis of the car and parallel to the track.





Set-up (4/5)

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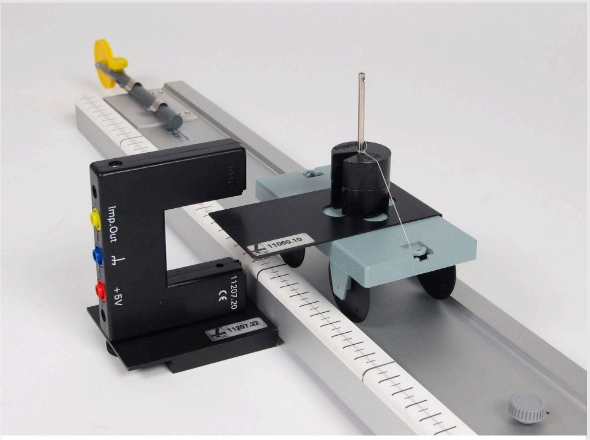

Connecting adapter plates with forked light barrier

Connect the adapter plate to the forked light barrier in such a way that it can be easily positioned next to the carriageway and the screen on the car can pass through the light barrier without hitting it.

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Set-up (5/5)

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Connect light barrier and timing device

Connect the light barrier to the time measurement device and set the rotary switch to the second position from the left. In this measurement setting, the light barrier measures the so-called shading time t, i.e. the duration for which the diaphragm interrupts the light beam when passing through the barrier.

Procedure (1/2)

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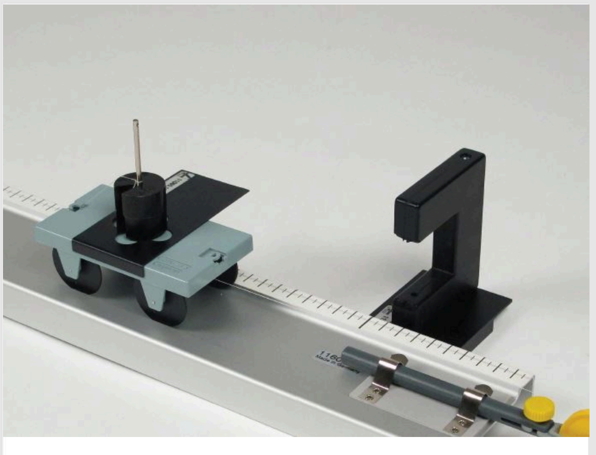

Experiment set-up

- Position the trolley at the point on the track where the weight plate just touches the floor when the thread is taut.
- Position the light barrier on the roadway so that it is interrupted by the diaphragm as soon as possible after the weight reaches the ground.
- Push the car from this point now around the track $s = 10\,cm$ uphill. Thereby the weight is increased by the same distance s raised. So now the route s equal in height h of the weight above the floor.

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Procedure (2/2)

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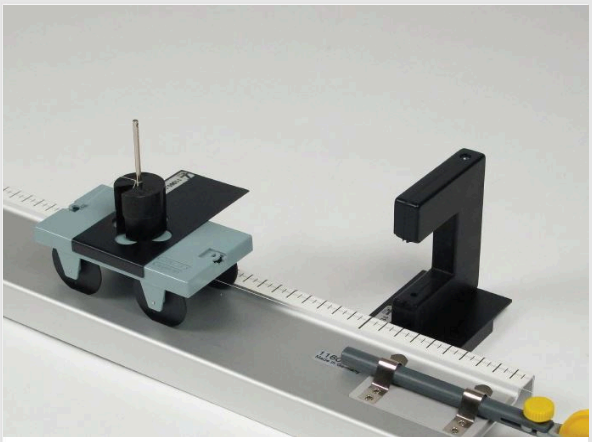

Experiment set-up

- Check whether the thread easily runs over the deflection pulley and whether it can be turned freely.
- Press the reset button on timer 2-1. button on timer 2-1, release the car without bumping it and catch it behind the light barrier.
- Note the shading time t.
- Repeat the measurement and increase the distance s, by lifting the weight with the trolley, in 10-cm increments up to $s = 60\,cm$.
- Record all resulting readings in Table 1 in the report.

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Report

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Table 1

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Carry the measured shading times t in the table.

Calculate from the shading times t and the aperture width $b = 5\,cm$ the terminal velocities $v = b/t$ 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 velocities 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				

Task 1

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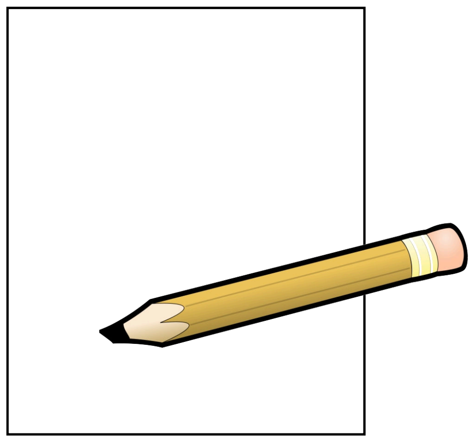
Now take a piece of paper and draw a diagram on it. In this diagram you put the potential energy E_{pot}($y$axis) as a function of the square of the velocity v^2 ($x$axis).



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Task 2

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What conclusions can be drawn from the course of the curve if it is taken into account that the potential energy has been converted into kinetic energy and thus v^2 represents the kinetic energy?

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

Check

Task 3

PHYWE

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

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

$m_{total} =$ [ ]

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

Think about what physical dimension the slope has and write that down as well.

$k =$ [ ] [ ]

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Task 4

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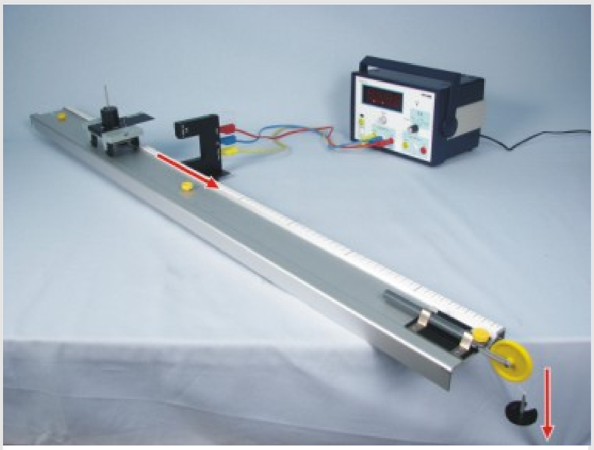

Experiment set-up

What unit does slope k have?

- kg/m^3
- Ncm
- kg
- m/s

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 the same as the value of the slope.
- ...is about twice the value of the slope.

Check

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Task 6

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

Then, from the measured data of the experiment, values can be obtained for the accelerated mass m_{exp} by multiplying the equation $\frac{1}{2} \cdot m_{exp} \cdot v^2 = E_{pot}$ to m_{exp}.

Calculate with it m_{exp} exemplary for some measurement series.

Can the experiment confirm the assumed equation... $E_{kin} = \frac{1}{2} \cdot m \cdot v^2$?

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

Check

Slide	Score / Total
Slide 20: Inferences of the diagram	0/2
Slide 22: unit of k	0/1
Slide 23: Mass comparison	0/1
Slide 24: Evidence of the law	0/1

Total 0/5

Solutions Repeat Export text

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