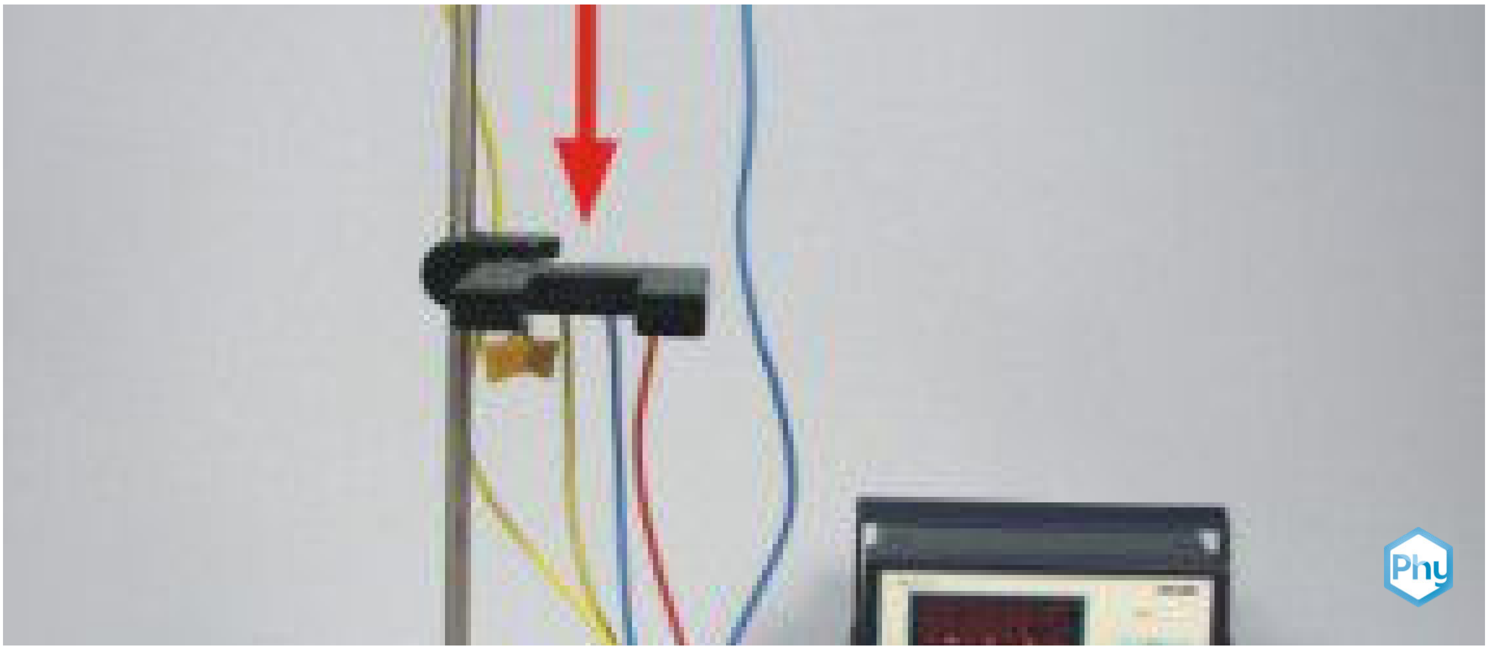
Free fall with the 2-1 timer



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/5fdbb8ec5098f00003f1edf2

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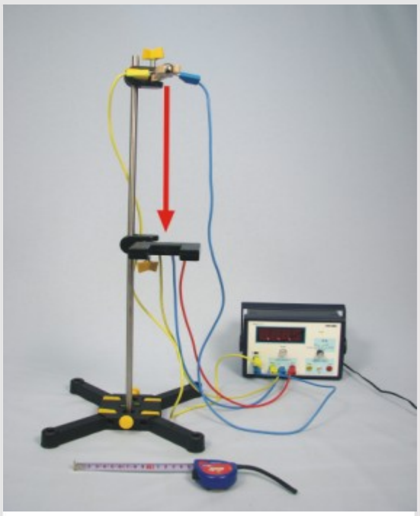
Teacher information

Application



Experiment set-up

We encounter free fall in everyday life wherever things fall to the ground. History even says that Isaac Newton first got the idea for his theories and conclusions on mechanics and gravitation and their transfer to celestial mechanics from an apple falling from a tree.

However, the lower the density of the falling body and the larger its surface, the more the free fall becomes a less accelerated, or decelerated fall. In a vacuum, however, all objects fall at the same rate.

The acceleration due to gravity $g = 9,81\, m/s^2$ is by no means a constant: it becomes smaller with increasing distance from the earth's surface.

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Other teacher information (1/2)

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Prior knowledge

Students should be familiar with the concepts of velocity and acceleration, and potential and kinetic energy. They should know that the gravitational force follows from the acceleration due to gravity. Furthermore, students should be mathematically able to determine the slope of a straight line and to perform a dimensional analysis of the slope found.

Scientific principle

The mass of the steel ball experiences a constant rectified force in the gravitational field of the earth, which accelerates the ball uniformly.

Friction effects on air are negligible in the context of this experiment, as is the buoyancy of the sphere due to the air surrounding it.

Other teacher information (2/2)

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Learning objective

In this experiment, the students are asked to experimentally determine the acceleration due to gravity g, and recognize that free fall is a uniformly accelerated motion.

Tasks

1. The students drop a steel ball from a holder and measure the drop times for different drop heights h with the help of two light barriers.
2. Examine the resulting measured values for drop distance h and fall time t for laws, which connect the two sizes and calculate from them finally value of the acceleration due to gravity g.

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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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Free fall in the amusement park

Free fall occurs wherever an object is dropped from a certain height. This applies to a drop tower in an amusement park as well as to bungee jumping, parachute jumping or jumping from a 10 m tower in an outdoor swimming pool.

As you know, the fall time depends on the mass of the falling body and the acceleration due to gravity. In addition, there is generally a deceleration due to air resistance.

In this experiment, you determine the height-dependent fall times of a sphere with the aid of two light barriers, investigate the given laws and use them to determine the acceleration due to gravity.

Tasks

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1. Drop a steel ball from a holding clamp and measure the time t required for the ball has to pass for the given drop height h. Repeat the experiment for different drop heights.
2. Examine the measured data for regularities that link the measured quantities of height of fall and time of fall and determine the acceleration due to gravity from the measured values.

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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	2
4	Measuring tape, l = 2 m	09936-00	1
5	Ball release unit	02505-00	1
6	Steel ball, d = 19 mm	02502-01	1
7	PHYWE Timer 2-1	13607-99	1
8	Light barrier, compact	11207-20	1
9	Connecting cord, 32 A, 1000 mm, red	07363-01	1
10	Connecting cord, 32 A, 1000 mm, yellow	07363-02	2
11	Connecting cord, 32 A, 1000 mm, blue	07363-04	2

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Set-up (1/3)

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Screwing the support rods

Set up the support.

To do this, screw the split support rods together and fasten them vertically in the assembled support base.

Attach a boss head at the very top of the long support rod and a second one halfway down.

Attach boss heads to support rod

Set-up (2/3)

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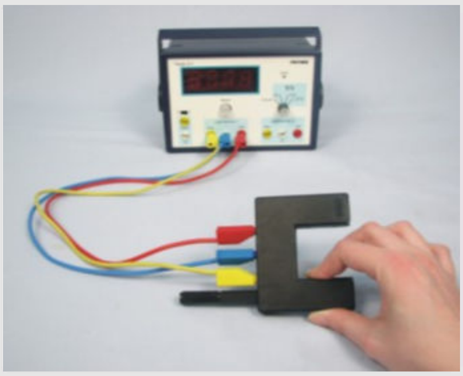
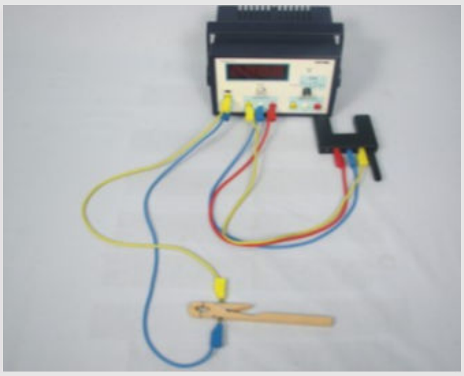
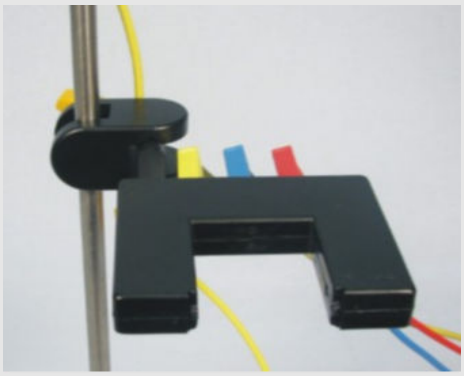
Screw the holding pin to the forked light barrier so that it can be held in the double socket. Connect the light barrier to the timing device. Plug one yellow and one blue cable into the sockets on the clamp. Plug the other ends of the cables into the two sockets in the "Start" field. The polarity does not matter here. Clamp the light barrier horizontally into the lower boss head.







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Set-up (3/3)

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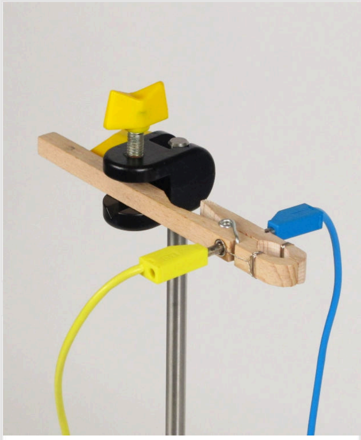
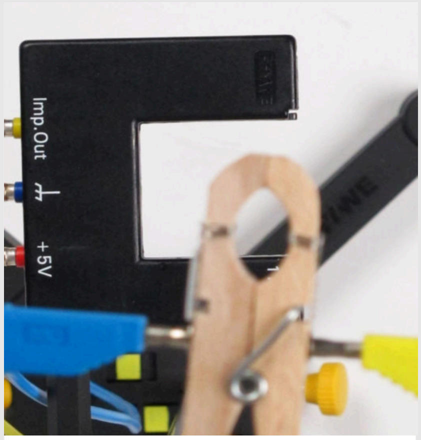


Ball release unit horizontally in the boss head

Clamp the light barrier horizontally into the lower sleeve. The hole of the ball release unit must be aligned with the light beam of the light barrier when viewed from above. On the timing device, set the slide switch above the field labeled "Start" to the left position so that opening the circuit at the "Start" input of the timing device starts the stopwatch.

Set the rotary switch on the timing device to the third position from the left. The timing device then displays the time that has elapsed between the interruption of the start circuit and the light barrier.



Align the hole of the ball release unit with the light barrier.

Procedure (1/2)

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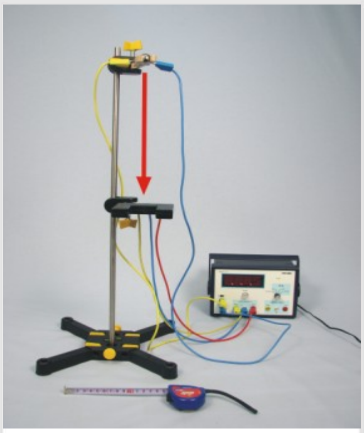

Experiment set-up

- Before each measurement, press the "Reset"-button on the timing device only after the ball has been clamped into the ball release unit and the contacts of the start circuit are closed. The timing will then start when the circuit is opened.
- Using the measuring tape, determine the distance between the lower edge of the ball in the release unit and the middle seam of the light barrier. $h = 7,5\,cm$ on.
- Note: Always clamp the ball in the release unit in the same way.

(The lower light barrier should still be mounted high enough in each partial experiment so that you can catch the ball underneath with your hand).

- Now open the release as quickly as possible.

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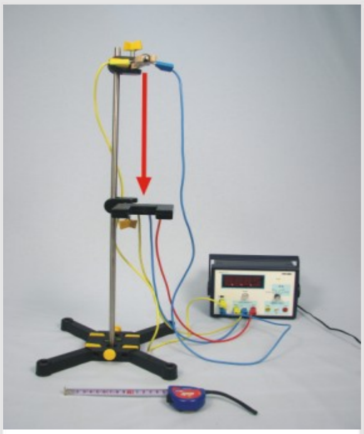
Procedure (2/2)



Experiment set-up

- Read off the fall time on the measuring device and enter it in Table 1 of the report.
- Check whether you get the same values with repeated measurements. If not, check that the ball is making proper contact and that you are clamping the ball the same way each time.
- If the ball does not hit the light beam of the lower light barrier or touches the light barrier housing or you have measured times greater than 0.5 s, then adjust the drop distance and repeat the measurement until you get a reproducible result.
- Change the distance from the lower edge of the ball to the middle seam of the light barrier successively to 10 cm, 15 cm, 20 cm, 30 cm, 40 cm, 45 cm and repeat the time measurements.

Report

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Table 1

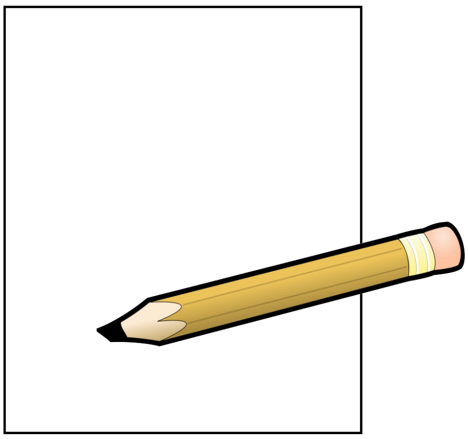
Carry the fall times t in the table.

then calculate from this the squared fall times t^2 and enter them in the table as well.

h $[cm]$	$t\,[s]$	$t^2\,[s^2]$
7,5		
10		
15		
20		
30		
40		
45		

Task 1

Now take a sheet of paper and create a diagram on it. In this diagram you set the height h (y-axis) as a function of the square of the fall time t^2 ($x$axis).



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Task 2

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Consider the measured values. Which statements are correct?

- [ ] With a quadrupling of the drop height h the fall time doubles t
- [ ] The fall time t grows underproportionally with the height of fall h.
- [ ] Since with a doubling of the fall height h, the fall time t does not also double, the speed must change during the fall.
- [ ] The fall time t grows disproportionately with the height of fall h.

Check

Task 3

PHYWE

For Table 1, a graph was plotted in which the drop height h versus the square of the fall time t^2. You should get a decent linear relationship.

Investigate the dimension of the slope k of the origin line, i.e. the proportionality factor between h and t^2 and choose the right unit!

- ○ $[k] = m/s^2$ - acceleration.
- ○ $[k] = N/m^2$ - pressure.
- ○ $[k] = m/s$ - speed.

Check

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Task 4

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What would a diagram look like in which the height of fall h against the time t would have been plotted?

- The result would be a shifted parabola.
- This would result in a root-shaped course.
- This would result in a straight line of origin.
- This would result in a parabola through the origin.

Check

Task 5

PHYWE

Calculate the numerical value of the slope k from the origin line and enter it below

$k =$ ____ $/s^2$

For a uniformly accelerated motion with acceleration a applies to the t distance travelled s $s = 1/2 \cdot a \cdot t^2$.

In this experiment, the drop height h the distance covered s in the diagram. Calculate the acceleration with this information a and enter the value in the window.

$a = 2k =$ ____ s^2

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Slide	Score / Total
Slide 18: Conclusions of the measured value	**0/3**
Slide 19: Inferences of the diagram	**0/1**
Slide 20: Consideration of h(t)	**0/1**

Total 0 / 5

Solutions Repeat Export text

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