# Chem-Tech

# PHYSICS LAB

## Free fall

**Certificates : ISO 9001 : 2015 - ISO** 14001 : 2015 - ISO 13485 : 2016 - GMP –CE
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# Free fall with

| Physics | Mechanics | Dynamics & Motion |
|---|---|---|

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

# Teatcher Information

## Application

Experiment set-up

In everyday life we encounter free fall wherever things fall to the ground. The story even says that Isaac Newton only got the idea of his theories and conclusions about mechanics and gravity and their transfer to celestial mechanics through 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 strongly accelerated or braked fall. In a vacuum, however, all objects fall at the same speed.

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

# Other teacher information (1/2)

**Prior knowledge**

Students should be familiar with the concepts of velocity and acceleration as well as potential and kinetic energy. They should know that the force of gravity relates with the acceleration of gravity. Furthermore, the students should be mathematically able to determine the gradient of a straight line and be able to perform a dimensional analysis of the gradient found.

**Scientific principle**

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

Frictional effects in air are negligible in this experiment, as is the buoyancy of the ball by the surroundingair.

# Other teacher information (2/2)

**Learning objective**

In this experiment, the students are to measure the acceleration due to gravity g experimentally determine and recognize that free fall represents a uniformly accelerated movement.

**Tasks**

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

## Safety instructions

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

# Student Information

## Motivation

Free fall in a theme park

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

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

In this experiment you determine the height-dependent fall times of a sphere with the help of two light barriers, examine the given laws and thus determine the acceleration due togravity.

## Tasks

1. Drop a steel ball from a holding bracket and measure the time $t$ that will hold the ball for the given height of fall $h$ needed. Repeat the test for different drop heights.
2. Investigate the measurement data for regularities that link the measured variables height of fall and fall time and determine the acceleration due to gravity from the measured values.

# Equipment

| Position | Material | Quantity |
|---|---|---|
| 1 | Photogate master | 1 |
| 2 | Photogate slave | 1 |
| 3 | Support rod 60 cm | 1 |
| 4 | Bose head | 3 |
| 5 | Magnet switch | 1 |
| 6 | Tri base | 1 |
| 7 | RJ 45 connecting cable | 1 |
| 8 | Metallic balls | 1 |

## Procedure (1/2)

Experiment set-up

Using the measuring tape, set the distance between the middle positions of the two photogates to $h = 7,5\,\mathrm{cm}$.

Note: Always position the ball with the same minimum distance above the upper light barrier.

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

Now start a measurement and drop the ball.

Calculate the fall time from the measured values. To do this, drag the value of the light barrier $A$ from that of $B$ off. Enter the fall time in Table 1 of the Report.

## Procedure (2/2)

Experiment set-up

Check that you get the same values with repeated measurements. If not, check if the ball positions and drops the same way each time.

If the ball does not hit the light beam of the lower photogate or touches the photogate housing or you have measured fall times greater than 0.5 s, then adjust the fall distance and repeat the measurement until you get a reproducible result.

Then change the distance between the middle positions of the photogates one after the other to 10 cm, 15 cm, 20 cm, 30 cm, 40 cm and repeat the time measurements.

Note all resulting fall times in Table 1 in the Report.

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# Report

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## Table I

Enter the fall times $t$ into the table.

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

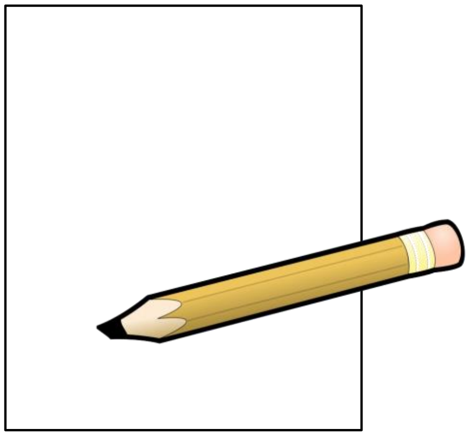
| h [cm] | t [s] | $t^2$ [$s^2$] |
|---|---|---|
| 7,5 | | |
| 10 | | |
| 15 | | |
| 20 | | |
| 30 | | |
| 40 | | |
| 45 | | |

## Task I

Now take a piece 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).

$$k = \frac{(\Delta T_2{}^2 - \Delta T_1{}^2) + 0.05}{h_2 - h_1}$$

$$a = 2 * k$$



## Task 2

Look at the readings. Which statements are correct?

- [ ] Since the fall time t when the height of fall is doubled h is not also doubled, the speed must change during the fall.
- [ ] The fall time t grows underproportionately with the height of fall h.
- [ ] If the height of fall is quadrupled h the falling time doubles t
- [ ] The fall time t grows overproportionately with the height of fall h.

Check

## Task 3

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A graph was created for Table 1, in which the height of fall $h$ versus the square of the fall time $t^2$ was applied. You should get a proper linear correlation.

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

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

Check

## Task 4

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What would a diagram look like, in which the height of fall $h$ against the time $t$ ...would be required?

- [ ] This would result in a shifted parable.
- [ ] This would result in a parable through the origin.
- [ ] This would result in a straight line of origin.
- [ ] This would result in a root-shaped course.

Check

# Task 5

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

k [m/s^2]

$k =$ ______ $/s^2$

For a uniformly accelerated movement with acceleration $a$ is valid for the periods of time $t$ distance traveled $s$ the context $s = 1/2 \cdot a \cdot t^2$.

In this experiment, the height of fall $h$ defines the distance travelled $s$. Use this information to calculate the acceleration $a$ and enter the value in the window.

$a = 2k =$ ______ $s^2$

| Slide | Score/Total |
|---|---|
| Slide 10: Conclusions of the measured value | **0/ 3** |
| Slide 11: Conclusions of the diagram | **0/ 1** |
| Slide 12: Consideration on h(t) | **0/ 1** |

**Total amount** **0/ 5**

Solutions Repeat Exporting text