Free fall with timer 2-1 **(Item No.: P2130702)**

Curricular Relevance

Area of Expertise:	**Education Level:**	**Topic:**	**Subtopic:**	**Experiment:**
Physics	University	Mechanics	Motion in one Dimension	Free fall with timer 2-1

Difficulty	**Preparation Time**	**Execution Time**	**Recommended Group Size**
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Easy	10 Minutes	10 Minutes	2 Students

Additional Requirements:

Experiment Variations:

Keywords:

Linear motion due to constant acceleration, laws of falling bodies, gravitational acceleration

Introduction

Overview

A sphere falling freely covers certain distances. The falling time is measured and evaluated from diagrams. The acceleration due to gravity can be determined.

Fig. 1: Experimental set-up

Equipment

Position No.	Material	Order No.	Quantity
1	Release unit	02502-00	1
2	Impact switch	02503-00	1
3	Timer 2-1	13607-99	1
4	Support base DEMO	02007-55	1
5	Right angle clamp PHYWE	02040-55	2
6	Plate holder	02062-00	1
7	Cursors, 1 pair	02201-00	1
8	Meter scale, l = 1000 mm	03001-00	1
9	Support rod PHYWE, square, l = 1000 mm	02028-55	1
10	Connecting cord, 32 A, 1000 mm, red	07363-01	2
11	Connecting cord, 32 A, 1000 mm, blue	07363-04	2

Tasks

1. Determine the functional relationship between height of fall and falling time $\left(h = h(t) = 1/2g \cdot t^2\right)$.
2. Determine the acceleration due to gravity.

Set-up and procedure

Fig. 2: Settings and connection to timer 2-1

The set up is shown in Fig. 1.
Connect the release unit to the “Start” sockets of the timer 2-1 and set the slide switch to rising edge ↑ (Fig. 2). Connect the impact switch to the “Imp.” and the ground socket associated with “Light barrier 1”. Set the rotary switch to mode ↑⊓↑ for time period measurement.
To adjust the pan of the impact switch, use the adjusting screw under the arrest switch. A downward motion of a few tenths of a millimetre should close the stop circuit. The pan is raised by hand after each single measurement (initial position). For the effective determination of the height of fall using the marking on the release mechanism, the radius of the sphere must be taken into account (diameter 3/4 inch, approx. 19 mm). The aerodynamic drag of the sphere can be disregarded.
Press the “Reset” button anew for every measurement.

Fig. 2: Settings and connection to timer 2-1

Theory and evaluation

If a body of mass m is accelerated from the state of rest in a constant gravitational field (gravitational force $F_g = m \cdot \vec{g}$), it performs a linear motion. By applying the coordinate system in a way that the x-axis indicates the direction of motion and solving the corresponding one-dimensional equation of motion, we get:

$$m\frac{d^2 h(t)}{dt^2} \tag{1}$$

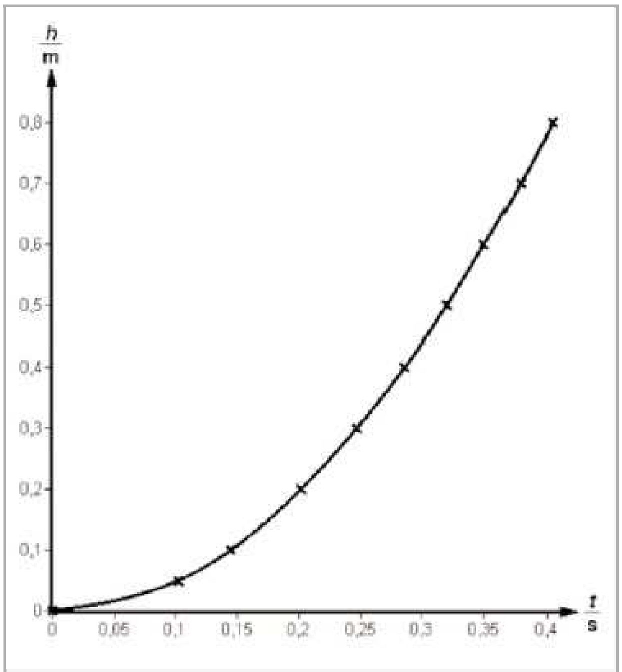

Fig. 3: Height of fall as a function of falling time

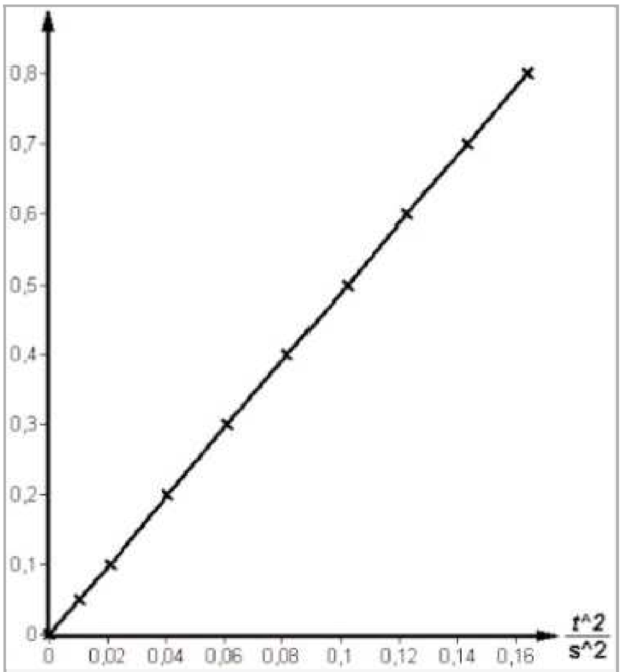

Fig. 4: Height of fall as a function of the square of falling time

We obtain for the initial conditions $h(0) = 0$

$$\frac{dh(0)}{dt} = 0 \tag{2}$$

the coordinate h as a function of time (see Fig. 3):

$$h(t) = \frac{1}{2} g t^2 \tag{3}$$

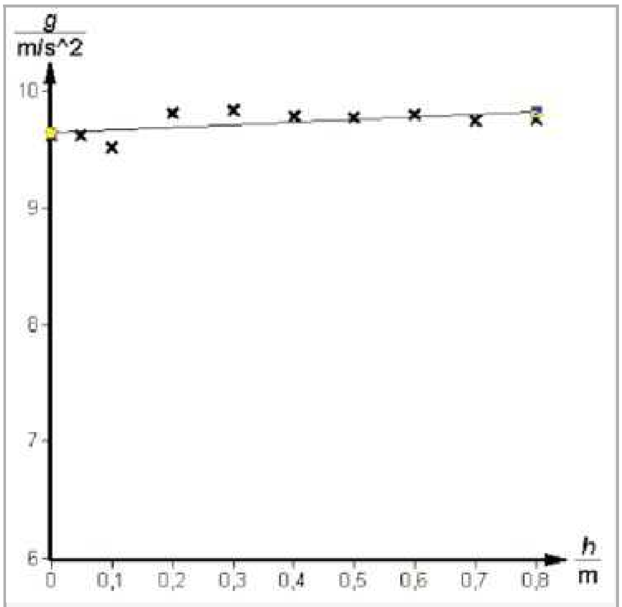

Fig. 5: Measured values of the gravitational acceleration

The height is directly proportional to the square of time. This can be displayed by a representation of $h(t_2)$ as shown in Fig. 4. From the regression line of the data, we can calculate the gravitational acceleration because the slope is equal to $\frac{1}{2}$ g according to equation (3).
For this measurement, we receive:
$g = 9.77$ m/s^2 (theoretical value: 9.81 m/s^2
Fig. 5 shows the values of the gravitational acceleration for different measurements (with different heights of fall).