Laboratory of Physics 1
Institute of Physics – CSE
Silesian University of Technology

P1-M1. Determining the acceleration due to gravity using the free fall method

Theoretical background

Gravity force. Acceleration due to gravity, unit, dependence of value on geographic latitude and altitude above sea level. Equation of uniformly accelerated rectilinear motion. Derivation of the relationship between time of fall and height.

1 Introduction

Free fall → textbook OpenStaxx.

2 Measuring system

The main element of the measurement system is a stand with a millimeter scale. The stand is equipped with an electromagnet which holds a metal ball and releases it after pressing the GO button on the control panel. At the moment of releasing the ball, the measurement of the time of motion starts until the ball intersects the light beam in the photocell F (as shown in the figure). The time in which the metal ball falls vertically without initial velocity on the path from the starting position to the photocell position is subject to measurement.

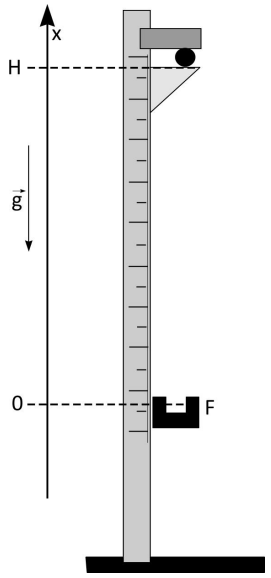

Fig.1: Schematics of measurement system

3 Measurements

1. Set on the control panel
   - TIME RESOL - .001
   - FUNCT MODE - two rectangular signal
   - START MODE - EL.M.+TIMER
2. Set the photocell at the selected height.
3. Measure the time of free fall of the ball. Repeat five times for ten different heights.
4. Place the results in a table.

No.	H, m	t, s					$\bar{t}$, s
		1	2	3	4	5	
1.							
⋮							

4 Data analysis

1. Calculate the values $\sqrt{H}$.
2. Calculate the average values of fall times $\bar{t}$.
3. Calculate the type a (statistical) uncertainties $u_a(\bar{t})$ of the mean time of fall.
4. Assuming equal accuracy of each measurement at the level of 3 significant digits, calculate the type b uncertainty $u_b(t)$ of the time measurement.
5. Calculate the total uncertainties of the mean times of fall. $u(t) = \sqrt{u_a^2(\bar{t}) + u_b^2(t)}$.
6. Place all the results in a table.

No.	H, m	$\sqrt{H}$, $\sqrt{\text{m}}$	$\bar{t}$, s	$u(\bar{t})$, s
1.				
⋮				

7. Prepare a graph of the dependence $\bar{t}(\sqrt{H})$. Plot the uncertainty bars.
8. Using linear regression, determine the coefficients of the line $\bar{t}(\sqrt{H})$ and their standard uncertainties. Plot the line on the graph. Does the line go beyond the uncertainty bars?
9. Based on the slope coefficient of the line, determined in point 8, and using the equation of motion, determine the acceleration due to gravity g.
10. Using the law of uncertainty propagation, calculate the uncertainty of the determined value of g.
11. Calculate the expanded uncertainty.
12. Conduct a conformity test of the obtained value with the value of the acceleration due to gravity calculated for the geographic latitude and altitude above sea level for Gliwice city.