# SIMPLE PENDULUM

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SIMPLE PENDULUM

Period of a simple pendulum as a function of the amplitude, mass and length.

**Didactic purposes**

To present an experimental inductivist methodology.

To stimulate skills related to experimental design, data collection and data analysis.

Enrich the activity in the dynamic environment of GeoGebra by adjusting a proposed model.

**Definitions**

Simple pendulum: oscillator consisting of a particle of mass **m** which is suspended from a fixed point by a thread inextensible of negligible mass. The oscillation amplitudes must be small compared with the length of thread. Considering the amplitude angularly, this one should not be greater than 10º.

Period: time it takes the pendulum to execute a complete oscillation.

**Construction**

Materials: sewing thread and washers. Tie one or more washers on one end of the sewing thread. The other end is attached to the point of suspension **A**. The length of the pendulum is **L** and **α** is the angular amplitude.


**Measurements**

The period is measured using a stopwatch. To reduce the error that occurs when starting and stopping the stopwatch: you can measure the time of 10 complete oscillations and then divide this time by 10. If you use the stopwatch of a cell phone do not consider the hundredths.

**Method**

The period depending of amplitude

A length and number of determined washers are chosen and the amplitude is varied by measuring the corresponding period.

For example, a length of 80 centimeters is taken and 1 washer is hung. The washer is separated from the vertical and the period is measured. This separation can be increased by one centimeter. Remember that the angular amplitude should not exceed $10^o$ (there should be no changes in the period)

The period depending of mass

You choose certain length and amplitude and is made to vary the number of washers by measuring the corresponding period.

For example, it is taken as length 80 centimeters and separated from the vertical by 10 centimeters, the period is measured and repeated by adding one washer at a time. (There should be no changes in the period)

The period depending of length

An amplitude and number of specific washers are chosen and the length is varied by measuring the corresponding period, for example, we can start with 40 and finish with 150 centimeters. These are the data that are loaded in GeoGebra

Dynamic environment

The experimental points (length, period) are loaded in GeoGebra. Two sliders **a**, **b** and the function $\mathbf{f(x) = a\ x^b}$ are defined. The sliders allow to visually adjust the function to the experimental points.

**Activity 1.**

Construction of the pendulum. Choice of measuring instruments. Analysis of the variables. Design of the experiments.

**Activity 2.**

Collection of experimental data. Analysis. Proposal of a potential mathematical model of the period depending on the length

Comment: Previously, different models can be compared in the spreadsheet view.

**Activity 3.**

Visual adjustment of the model in GeoGebra.

**Activity 4.**

Historical research, Galileo, Huygens and clocks.

**Activity 5.**

Determine the acceleration of gravity. Investigate the solution of the problem within the framework of the dynamics. The results for the period of the equation of the simple harmonic motion is:

$$T(x) = \frac{2\pi}{\sqrt{g}}\sqrt{x}$$

Where **T** is the period and **x** is the length of the pendulum. It is observed that the period does not depend on mass or amplitude.

By comparison with the model fitted with GeoGebra, the value of ***g*** can be obtained.

$$f(x) = ax^b \qquad T(x) = \frac{2\pi}{\sqrt{g}}\sqrt{x} \qquad \rightarrow \qquad g = \left(\frac{2\pi}{a}\right)^2$$