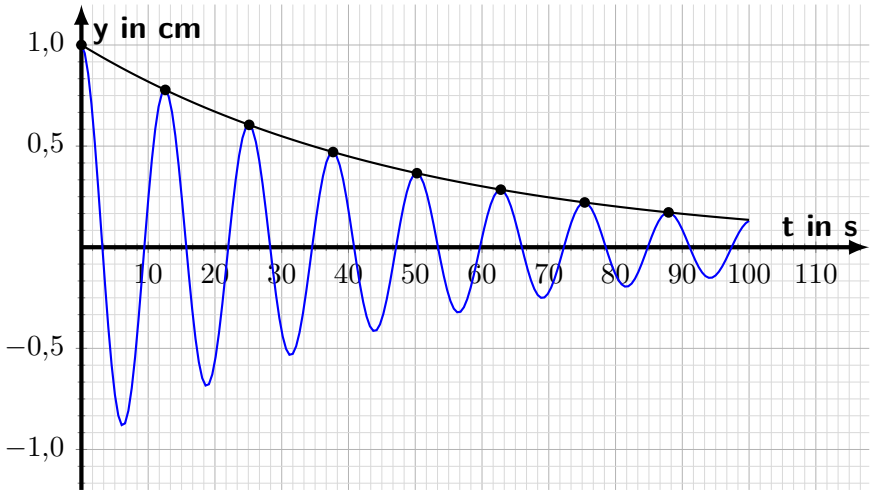
Damped Oscillation

Task

Determine the damping factor of a pendulum.

Preliminary Consideration

The following diagram shows an idealized damped oscillation.



1. The envelope (black graph) describes the damping of the oscillation. For the graph, the following general equation applies:

$$y(t) = y_0 \cdot e^{-\delta t}$$

   Describe the influence of the quantities y_0 and δ on the graph.

2. Show that for the factor δ the following holds:

$$\delta = -\frac{1}{t} \ln \frac{y(t)}{y_0}$$

3. The damping of a pendulum depends on various factors.
   Formulate **one** hypothesis that you can test using the given setup.

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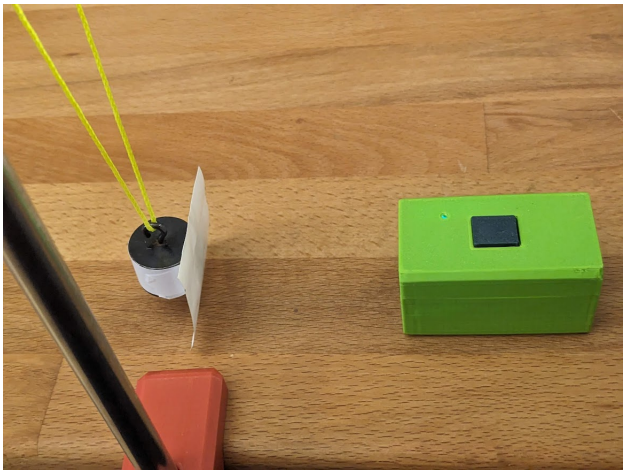
Procedure

1. Hang the pendulum in its rest position and position the ToF sensor at the height of the pendulum.

   Experimental Setup

2. Use the button on the sensor to set the offset so that the point of rest is set to 0.
3. Displace the pendulum by a small angle and start the measurement with phyphox.
4. Save the measurement on your device. (Open the menu behind the three dots and click on *Save State*.)
5. Repeat the measurement, varying one parameter according to your hypothesis.

Evaluation

1. Extract at least five amplitudes as a function of time from the $y(t)$ diagrams in phyphox. To do this, enlarge the s(t) diagram and use the cursor to select the corresponding amplitudes. Since the time does not start at 0 s, subtract the start value of the time from your read values so that the first displacement is at $t = 0$.
2. Determine the damping factors δ of the respective oscillation using the measured values.
3. Verify your hypothesis, considering possible measurement uncertainties.

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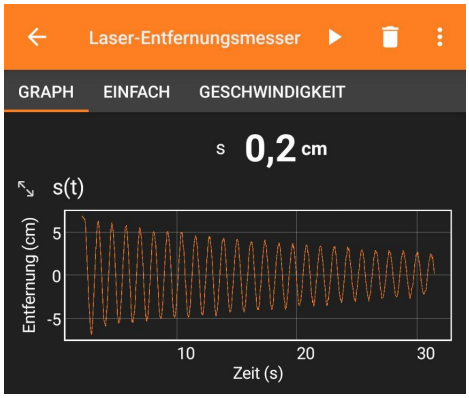
Notes and Expectations

Example Graph



Example Measurements at Different Intervals

t in s	t_i in s	y in cm	δ
2.90	0	6.9	–
6.33	3.43	5.5	0.066
9.82	6.92	4.9	0.049
14.41	11.51	4.3	0.041
23.71	20.81	3.2	0.037
30.52	27.62	2.2	0.041

$$\overline{\delta} = 0.047$$

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