Damping with Cobra SMARTsense

In this experiment, students are asked to observe the amplitudes of vibration over long periods of time and to know and measure their decrease with time.

Physics → Mechanics → Vibrations & waves

Difficulty level	Group size	Preparation time	Execution time
easy	2	10 minutes	10 minutes

This content can also be found online at:

http://localhost:1337/c/6123a85ce3e7380003d48737

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

Teacher information

Application

Damping with SMARTsense

So far, the students have conducted experiments on idealized oscillations in which influences due to friction, damping and air resistance are neglected. In fact, however, every oscillation experiences damping, which causes the amplitude of the oscillation to decrease over time.

Here the free damped oscillation can be described as a decreasing e-function as follows:

$x(t)= x_0 \cdot {\rm e}^{-\delta t} \cdot \cos(\omega\,t+\varphi_0)$

With initial deflection $x_0$the angular frequency ω and the phase shift φ_0 at the beginning of the oscillation.

Robert-Bosch-Breite 10
37079 Göttingen
Tel.: 0551 604 - 0
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info@phywe.de
www.phywe.de

Teacher information (1/2)

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Prior knowledge

Students should already be familiar with the helical spring pendulum and the acceleration due to gravity. g and its averaged value $9,81\,m/s^2$as this value plays a major role in the oscillation behaviour of each pendulum.

Scientific Principle

The amplitude of a free, damped oscillation decreases with time. This phenomenon is sometimes due to the damping of the system. This results, for example, from the air resistance of the coil spring pendulum or from the damping in the material of the spring.

Note: The damped oscillation can be described with the help of an e-function. In this case, the e-function should have been treated mathematically in advance. It does not necessarily have to be introduced in the context of this experiment.

Teacher information (2/2)

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Learning objective

The students should observe the amplitudes of vibration over longer times and learn about and measure their decrease with time. This leads to the concept of damping, which is to be introduced here primarily qualitatively and not as the commonly used logarithmic damping decrement.

Tasks

1. The students let a thread pendulum swing freely in air and measure the deflection after different times. They also compare the deflection with the original deflection, then attach a disc to the thread pendulum and repeat the measurement.
2. The students immerse the mass of the pendulum in water and investigate the deflection after different times.

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Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
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info@phywe.de
www.phywe.de

Safety instructions

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

Student Information

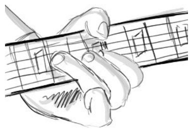
Robert-Bosch-Breite 10
37079 Göttingen
Tel.: 0551 604 - 0
Fax: 0551 604 - 107
info@phywe.de
www.phywe.de

Motivation

Damping with SMARTsense

Do vibrations occur in everyday life?

Whether when swinging on the playground, playing a musical instrument or generating clocks for electronic devices. Vibrations can be intentional (e.g. oscillating quartz in watches) or unintentional (e.g. vibrations when driving a car) .



In this experiment you will learn to observe the amplitudes of oscillations over longer periods of time and to know and measure their decrease with time.

Task

1. Let a thread pendulum oscillate freely in air and measure the deflection after different times. Compare the deflection with the original deflection. Then attach a disc to the thread pendulum and repeat the measurement.

2. Immerse the mass of the pendulum in water and examine the deflection after different times.

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Equipment

Position	Material	Item No.	Quantity
1	Cobra SMARTsense - Force and Acceleration, ± 50N / ± 16g (Bluetooth + USB)	12943-00	1
2	Support base, variable	02001-00	1
3	Support rod, l = 600 mm, d = 10 mm, split in 2 rods with screw threads	02035-00	1
4	Boss head	02043-00	1
5	Holding pin	03949-00	1
6	Helical spring, 3 N/m	02220-00	1
7	Weight holder, 10 g	02204-00	1
8	Slotted weight, black, 10 g	02205-01	4
9	Glass tube holder with tape measure clamp	05961-00	1
10	Digital stopwatch, 24 h, 1/100 s and 1 s	24025-00	1
11	Measuring tape, l = 2 m	09936-00	1
12	Beaker, 250 ml, plastic (PP)	36013-01	1
13	measureAPP - the free measurement software for all devices and operating systems	14581-61	1

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Robert-Bosch-Breite 10
37079 Göttingen
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info@phywe.de
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Additional material

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Position	Equipment	Quantity
1	Drawing cardboard	approx. DIN A4

Set-up (1/3)

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For measurement with the **Cobra SMARTsense sensors** the **PHYWE measureAPP** is required. The app can be downloaded free of charge from the relevant app store (see below for QR codes). Before starting the app, please check that on your device (smartphone, tablet, desktop PC) **Bluetooth** is **activated**.

iOS

Android

Windows

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Robert-Bosch-Breite 10
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Set-up (2/3)

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- Rotate the two-part tripod rod together (left figure).
- Assemble the tripod base and the tripod rod to a tripod (right picture).

Set-up (3/3)

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- Attach the force sensor in the double socket (left figure).
- Hang the coil spring on it (right figure).

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37079 Göttingen
Tel.: 0551 604 - 0
Fax: 0551 604 - 107
info@phywe.de
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Procedure (1/8)

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Switch on

Select sensor in measureAPP

- Turn on the force sensor by pressing the power button for several seconds.
- After successful switching on you will see a flashing LED (left picture).
- Start the measureAPP. Tap on the tab "Sensor" and select the force sensor (right figure).

Procedure (2/8)

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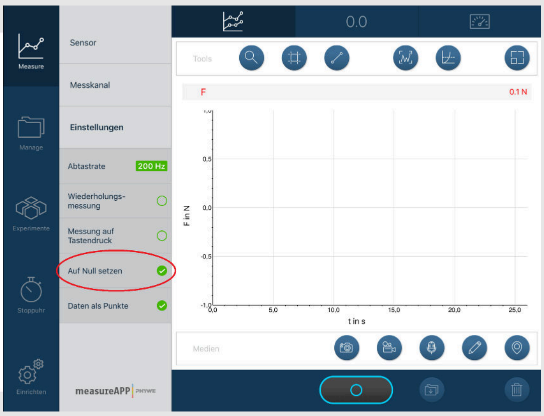
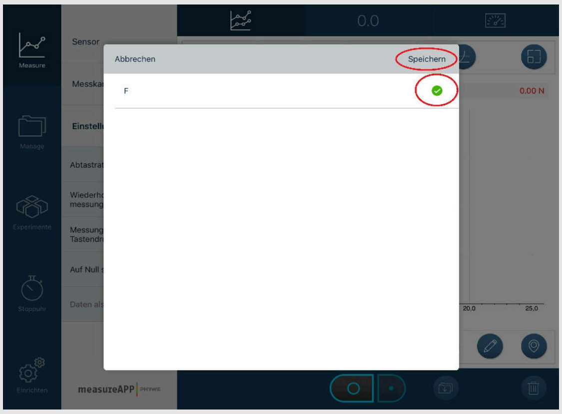
- Tap the "Settings" tab and select "Set to zero" (left figure). In the following window, tap on the force sensor.
- Exit the window by clicking on save (right image).





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Robert-Bosch-Breite 10
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Procedure (3/8)

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Execution - weight plate

- Hang the weight plate with a total mass of 150g on the eyelet of the coil spring.
- The spring should be completely at rest and not vibrate. Therefore, steady the system with your hand.

NoteTo attach the slotted weights to the weight plate, slide them over the top of the weight plate (see illustration).

Implementation (4/8)

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- Set the mass in oscillation. Make sure that the spring is only deflected vertically and does not move sideways.
- Make sure of this by observing the vibration for a few seconds.
- If the oscillation is not smooth, stop the spring and try again.

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Robert-Bosch-Breite 10
37079 Göttingen

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info@phywe.de
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Procedure (5/8)

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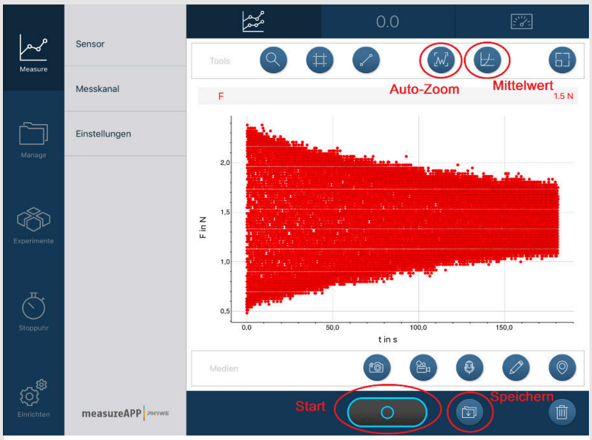

Execution - Start measurement

- Start the measurement (figure).
- Stop the measurement after three minutes (180 seconds).
- Use the auto-zoom function (figure).
- Find the mean value of the curve and write it down (figure).

Procedure (6/8)

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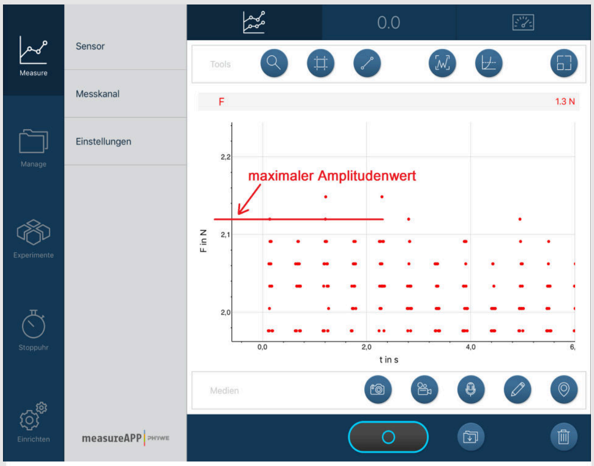

Execution - Maximum amplitude

- Read off the maximum deflection of the force at the start of the measurement and note it down (Figure). To do this, zoom with your fingers into the upper left corner of the trace.
- Use the auto-zoom function again. Read off the maximum displacement at the end of the measurement and note it down. To do this, zoom with your fingers into the upper right corner of the trace.
- Save the measurement.

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37079 Göttingen
Tel.: 0551 604 - 0
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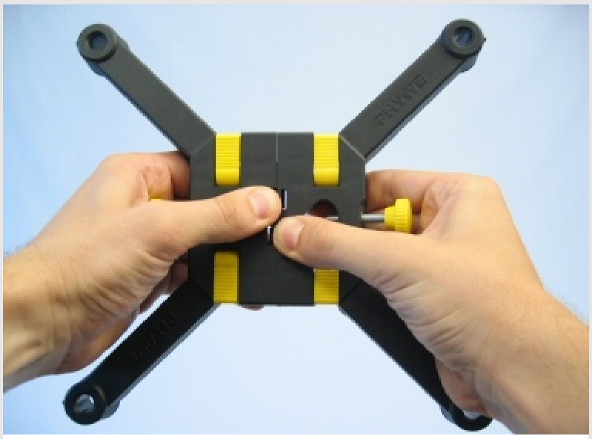
Procedure (7/8)

- Attach a circular cardboard disc to the center of the weight plate and repeat the entire measurement.
- Place the cup filled with water underneath the spring pendulum and immerse the weight plate so that the weight is in the middle underneath the water surface.
- Deflect the spring pendulum downwards from the equilibrium position until the weight reaches the bottom of the vessel. Then release the mass and simultaneously start the measurement for a duration of 10 seconds.

Procedure (8/8)



Feedthrough - Tripod base

- To disassemble the tripod base, press the buttons in the middle and pull both halves apart.

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Tel.: 0551 604 - 0
Fax: 0551 604 - 107
info@phywe.de
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Report

Task 1

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Give for the case of **free** oscillation displays the determined values:

mean force	
Force at max Deflection (start)	
Force at max	

Determination of mean value and deflection

The mean value of the force corresponds to the ______ of the spring pendulum. Via the relation ______ can therefore be used to determine the mass. The mean value must be divided by g ______. The difference between the forces at maximum deflection and the mean value corresponds to the spring force ______. If one divides this difference by the spring constant Done obtains the geometric ______.

$F = mg$ | divided | $.F = D \cdot x$ | deflection | rest position

Check

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Robert-Bosch-Breite 10
37079 Göttingen
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info@phywe.de
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Task 2

PHYWE

Give for the oscillation case with **Cardboard disc** displays the determined values:

mean force	
Force at max Deflection (start)	
Force at max	

Calculate the geometric deflections of the spring pendulum at the beginning and end of the measurement. Indicate by what percentage the amplitude has decreased and compare with the previous result. What stands out?

In task 1, the amplitude has decreased by ______. In task 2, it has decreased by about ______. This value is ______ than before. The reason for this is that the resistance in task 1 is ______ than the resistance caused by the cardboard disc.

higher | 60% | smaller | 75%

Check

Task 3

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Give for the vibration case **underwater** displays the determined values:

mean force	
Force at max Deflection (start)	
Force at max	

Calculate the geometric deflections in the same way as before. What stands out? What does the limit value 0 mean for the amplitude of the oscillation?

The amplitude dropped significantly ______ than the drops in air. The water provides a ______ resistance which slows the pendulum down quickly (only 10 seconds measurement). The amplitude of the oscillation has dropped ______, i.e. the oscillation has come to a ______.

stop | to zero | high | faster

Check

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Slide	Score / Total
Slide 23: Mean value and deflection	**0/5**
Slide 24: Geometric deflections of the spring pendulum	**0/4**
Slide 25: Geometric deflections of the spring pendulum	**0/4**

Total **0 / 13**

Solutions Repeat Export text

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Robert-Bosch-Breite 10
37079 Göttingen
Tel.: 0551 604 - 0
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info@phywe.de
www.phywe.de