Measurement of time

Physics | Mechanics | Fabric & material properties

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

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Teacher information

Application

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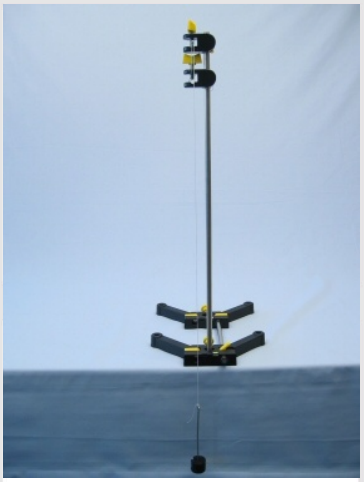

Test setup

The student should count the oscillations of a pendulum with the help of a stopwatch. In order to show the dependence of the period of oscillation on the pendulum length, the pendulum length is shortened to half in the 2nd part of the experiment. The oscillation period of a pendulum is

$$T = 2\pi \cdot \sqrt{\frac{l}{g}}$$

T: Time [s]

l: Length of the pendulum [m]

g = 9.81 m/s² (acceleration of gravity)

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Other teacher information (1/2)

Prior knowledge

The SI unit of time is the second (s). It is a basic unit of the SI system and defines the duration of 9 192 631 770 periods of radiation of the atom Cs133 at the transition between the two hyperfine structure levels in the ground state.

1 day (d) = 24 hours (h) = 1440 minutes (min) = 86400 seconds (s).

1 h = 60 min = 3600 s , 1 min = 60 s.

Principle

The full pendulum swinging is counted from the right (or left) reversal point. It is also possible to count them when passing through the pendulum's rest position. It should be noted that when a pendulum oscillates, the zero crossing occurs once in each direction: So in total two times per oscillation.

Other teacher information (2/2)

Learning objective

It is investigated to what extent the period of oscillation of a pendulum depends on its length: The students are to understand and internalize the connection between period of oscillation and pendulum length ($T \propto \sqrt{l}$).

Tasks

For this purpose, the students are to build a pendulum, deflect it and measure the time of the oscillations. They are to carry out this experiment with two different pendulum lengths:

1. $l = 99.4\,cm$
2. $l = 49.7\,cm$

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Safety Instructions

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

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Student Information

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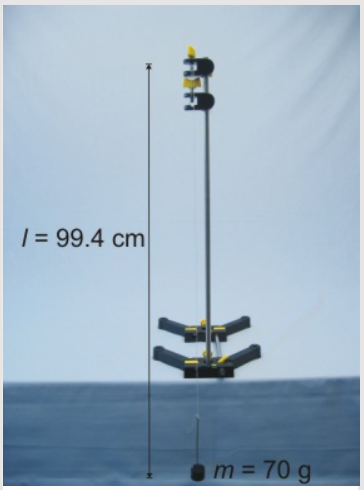
Motivation



Experiment Set-up

Pendulums are used in many technical areas. Therefore, a basic understanding of the physical relationships behind them is very important.

For example, pendulums are used in grandfather clocks, but are also used in high-rise buildings in earthquake-prone areas to attenuate the energy of the quake and thus protect the building from damage.

Tasks

Measure the time it takes the pendulum to swing with your stopwatch.

Change the pendulum length to half and measure the time for one oscillation again.

Measure at the following pendulum lengths:

- $l = 99.4\,cm$
- $l = 49.7\,cm$

The mass remains the same at both pendulum lengths.

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Material

Position	Material	Item No.	Quantity
1	Support base, variable	02001-00	1
2	Support rod, stainless steel, l = 250 mm, d = 10 mm	02031-00	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	2
5	Holding pin	03949-00	1
6	Weight holder, 10 g	02204-00	1
7	Slotted weight, silver bronze, 10 g	02205-02	1
8	Slotted weight, silver bronze, 50 g	02206-02	1
9	Fishing line, l. 20m	02089-00	1
10	Digital stopwatch, 24 h, 1/100 s and 1 s	24025-00	1
11	Measuring tape, l = 2 m	09936-00	1

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Additional material

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Position	Material	Quantity
1	Scissors	1

Set-up (1/4)

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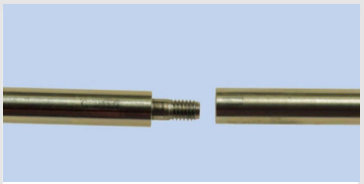

Support rods with thread

Support base

Set up a stand for the pendulum as follows:

1. First screw the two support rods together to form a long support rod

2. Now fix the short support rod horizontally between both feet. To attach the support rod, pull the yellow lever of the feet.

3. Screw the long support rod vertically into the support base.

Screw connection of the vertical support rod in the support base.

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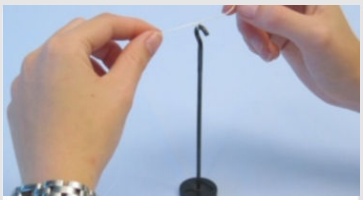
Set-up (2/4)

Fix holding pin at bosshead

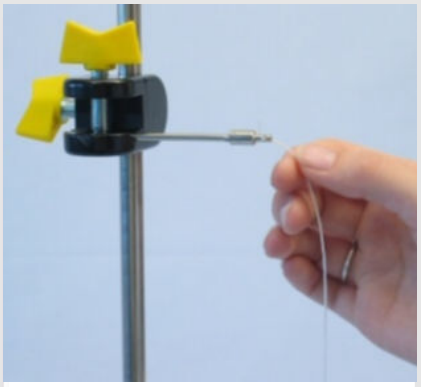


Attach fishing line

4. Use the upper bosshead to fix the holding pin so that the hole at its end is horizontal.

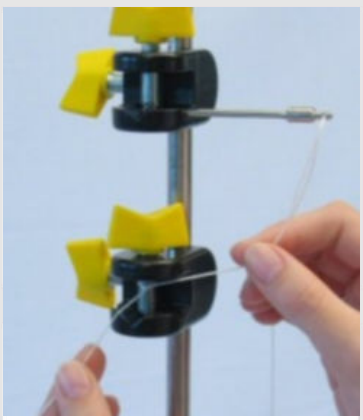
5. Tie one end of a piece of fishing line (approx. 1.10 m) to the hook of the weight holder.

6. Insert the other end through the hole in the holding pin.



Insert the fishing line in the hole

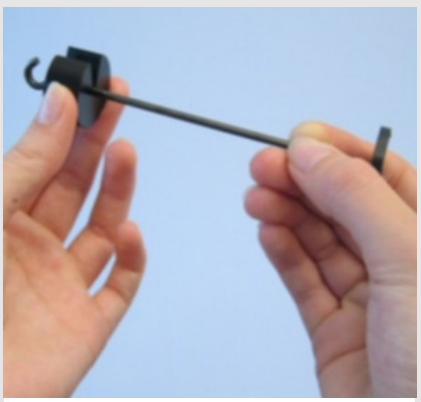
Set-up (3/4)



Fastening the fishing line with the help of a second bosshead

7. Tie the fish line to the second bosshead

8. Place weight on the weight holder so that the total mass is 70 g The illustration opposite shows how to place the weights on the weight holder.



Adding a slotted weight to the weight holder

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Set-up (4/4)

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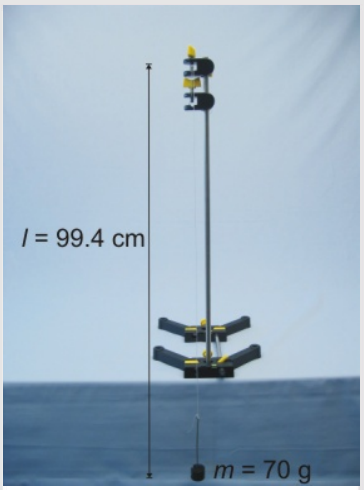

Experiment setup

9. Adjust the height of the lower bosshead so that the total length from the suspension point at the upper end to the middle point of the weight is as accurate as possible to 99.4 cm.

Procedure (1/3)

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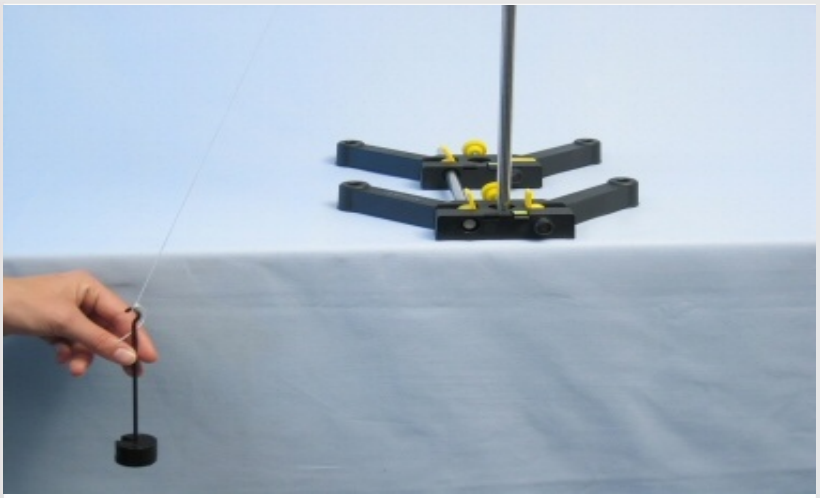
- Let the pendulum swing always parallel to the edge of the table, correct the setup and the starting position if necessary.
- Deflect the pendulum about 20 cm to the side and release it carefully. Start the stopwatch at the same time as you release it.



Deflection of the pendulum

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Procedure (2/3)

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- Stop the clock when the pendulum has completed an entire oscillation and read the time from the watch. Enter the value obtained under t1 in Table 1 in the report.
- Repeat the experiment by counting 20 oscillations now. Stop the stopwatch after 20 oscillations, read off the elapsed time and enter the measured value found under t_{20} also in Table 1 in the report.
- Repeat both steps four more times.

Procedure (3/3)

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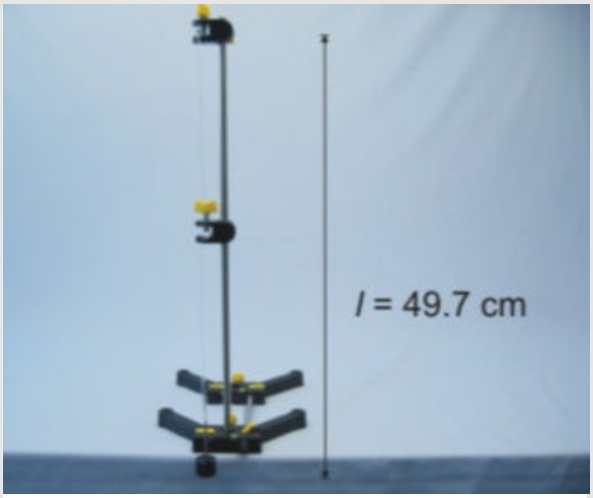

Halved pendulum length

- Now shorten the pendulum length by exactly half of the original length to exactly 49.7 cm by moving the lower bosshead downwards and if necessary by winding the fish line around it.
- Measure again five times the times for one and for 20 oscillations and enter the measured values in table 2 of the report.

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Report

Table 1

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Measurement No.	$t_1\ [s]$	$t_{20}\ [s]$
1		
2		
3		
4		
5		
Average value		

Enter your measured values for the pendulum length $l = 99.4\,cm$ in the table.

Calculate the average value (AV) of the time for 1 oscillation t_1 and t_{20} for 20 oscillations.

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Table 2

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Measurement No.	$t_1\ [s]$	$t_{20}\ [s]$
1		
2		
3		
4		
5		
Average value		

Enter your measured values for the pendulum length $l = 49.7\,cm$ in the table.

Calculate the average value (AV) of the time for 1 oscillation t_1 and t_{20} for 20 oscillations.

Table 3

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Pendulum length	$T_{1/2}$ [s]
99.4 cm	
49.7 cm	

Enter the average values for the period of oscillation T in the adjacent table.

Calculate the average oscillation time T dividing the average of t_{20} by 20.

The result should approximately correspond to the oscillation period for the measurement of the individual oscillations. If this is not the case, the measurement should be repeated if necessary.

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Table 4

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Pendulum length	$T_{1/2}$ [s]
99.4 cm	
49.7 cm	

Calculate the period for half an oscillation $T_{1/2}$ from the oscillation period T. Write the values in the Table.

Task 1

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The thus-determined value of T should be close to value (t_1) for one oscillation. Which result is probably more exact ?

- ○ Measurement after 1 oscillation.
- ○ Measurement after 20 oscillations.

Check

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Task 2

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How does the shortening of the pendulum length affect the period of oscillation?

- ○ Shortening the period of oscillation.
- ○ Extension of the oscillation period.

Check

Task 3

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Can you explain why a pendulum with a length of l = 99.4 cm is called a "pendulum of seconds"?

- ○ Because half an oscillation lasts exactly 1 second.
- ○ Because an oscillation lasts exactly 1 second.

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Task 4

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Form the ratio of the periods of oscillation of the two pendulums of different lengths. How large is it?

- ○ 2
- ○ $\frac{3}{2}$
- ○ $\sqrt{2}$

Check

Task 5

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Which proportionality is correct?

- ○ $T \sim \sqrt{l}$
- ○ $\sqrt{T} \sim l$
- ○ $T \sim l$

Check

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Slide	Score/Total
Slide 23: Comparison of the accuracy of the measurements	0/1
Slide 24: Shortening the pendulum length	0/1
Slide 25: Second Pendulum	0/1
Slide 26: Ratio of the oscillation periods	0/1
Slide 27: Proportionality	0/1

Total amount 0/5

Solutions | Repeat | Exporting text

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