Coupled pendulum systems (Item No.: P1003400)

Curricular Relevance

Area of Expertise: Physik
Education Level: Klasse 10-13
Topic: Mechanik
Subtopic: Schwingungen und Wellen
Experiment: Gekoppelte Pendel

Difficulty	Preparation Time	Execution Time	Recommended Group Size
Intermediate	10 Minutes	10 Minutes	2 Students

Additional Requirements:

- Scissors

Experiment Variations:

Keywords:

Task and equipment

Information for teachers

Additional Information

Using two coupled pendulums, the students should investigate how they interact and determine their beat frequency f_S.
Additionally, they should measure the oscillation frequencies for excitation in the same (f_1) and opposite senses (f_2).
In a supplementary problem they should determine the influence of the coupling on the beat frequency.

Remark

On changing the coupling:
The mass should only be reduced since, otherwise, the two thread pendulums will hang at an angle; this results in dubious measuring results. The attachment points for the coupling must not be placed too low since, otherwise, the frequency differences between excitation in the same and opposite directions would be too small and, consequently, the measuring errors too large.

Robert-Bosch-Breite 10
D - 37079 Göttingen
Tel: +49 551 604 - 0
Fax: +49 551 604 - 107
info@phywe.de
www.phywe.com

Coupled pendulum systems (Item No.: P1003400)

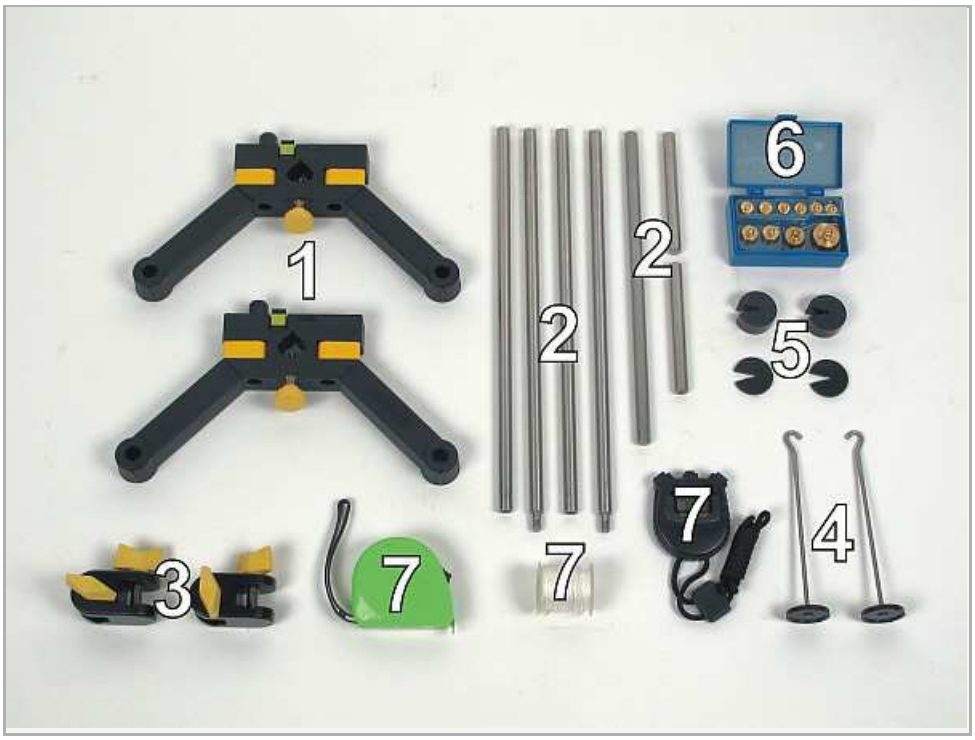
Task and equipment

Task

How do two coupled pendulums behave?

Observe the behaviour of two thread pendulums which are coupled by a thread and a mass piece.
Measure the beat period of the coupled pendulum.
Determine the oscillation period of both pendulums during oscillation in the same and opposite directions.

Equipment



Position No.	Material	Order No.	Quantity
1	Support base, variable	02001-00	1
2	Support rod with hole, stainless steel, 10 cm	02036-01	2
2	Support rod, stainless steel, l = 250 mm, d = 10 mm	02031-00	1
2	Support rod, l = 600 mm, d = 10 mm, split in 2 rods with	02035-00	2
3	Boss head	02043-00	2
4	Weight holder for slotted weights	02204-00	2
5	Slotted weight, black, 10 g	02205-01	2
5	Slotted weight, black, 50 g	02206-01	2
6	Set of precision weights,1g-50g	44017-00	1
7	Stop watch 4	03078-00	1
7	Measuring tape, l = 2 m	09936-00	1
7	Fishing line, l. 20m	02089-00	1
Additional material			
	Scissors		

Robert-Bosch-Breite 10
D - 37079 Göttingen
Tel: +49 551 604 - 0
Fax: +49 551 604 - 107
info@phywe.de
www.phywe.com

Set-up and procedure

Set-up

Connect the two halves of the support base with the 25 cm support rod and tighten the locking levers (Fig. 1).
Screw the splitted support rods together to get two long ones (Fig. 2).
Set the two 60 cm support rods into the support base halves, tighten them with the locking screws (Fig. 3).

Fig. 1

Fig. 2

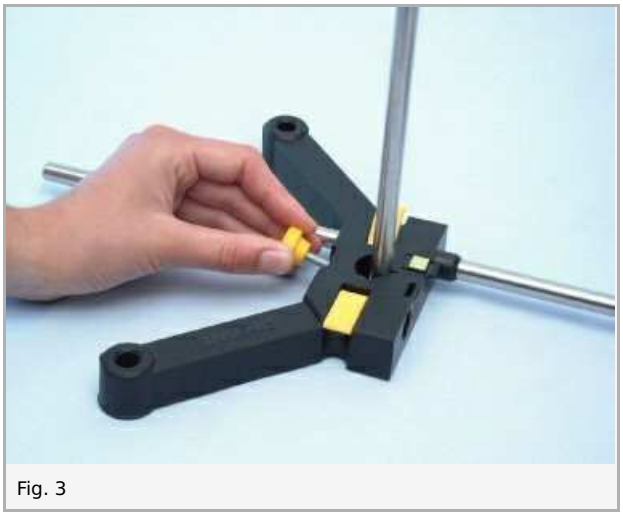


Fig. 3

Clamp the two short support rods into the bossheads (Fig. 4).

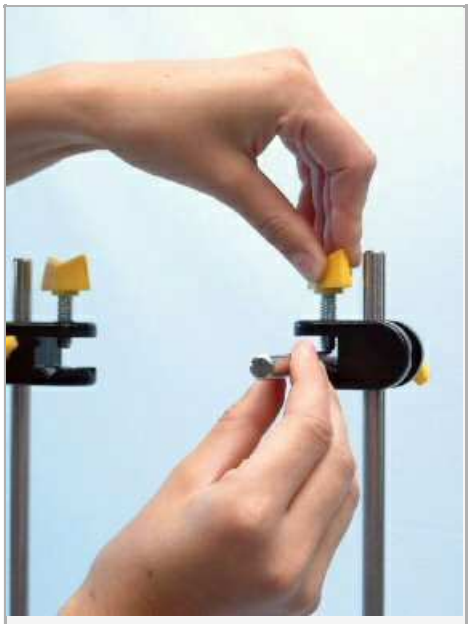


Fig. 4

- Set up two thread pendulums which are exactly the same.
- The pendulum length is 40 cm, the mass of each m = 70 g. The distance between the two suspension points should be 10 cm.
- Test to see whether the two pendulums have the same oscillation period! If necessary you must slightly change the length of one of the pendulums.
- Attach a 10 g mass piece with a short piece of fish line exactly in the middle of another piece (20 cm long).
- Couple the two pendulums with the latter piece of fish line by tying its ends to the upper ends of the weight holders (Fig. 5).

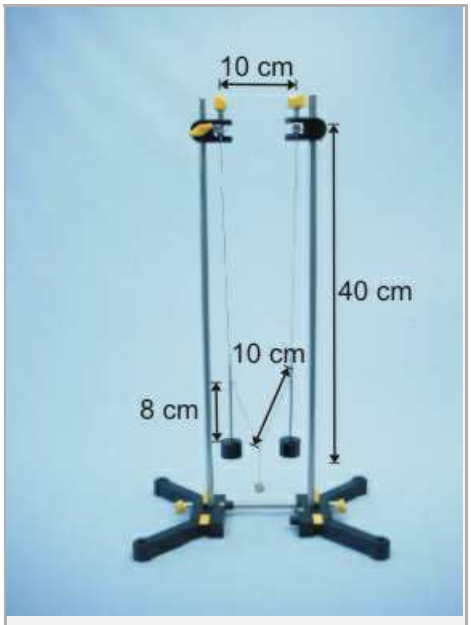


Fig. 5

Robert-Bosch-Breite 10
D - 37079 Göttingen
Tel: +49 551 604 - 0
Fax: +49 551 604 - 107
info@phywe.de
www.phywe.com

Procedure

- Initiate oscillation in the system by deflecting one of the pendulums laterally about 4 cm (Fig. 6). Release the pendulum, observe the behavior of both pendulums and note your observation in the report.
- Measure the beat period of the two coupled thread pendulums: to do this determine the time T_S between two standstills of one of the pendulums. Repeat the measurement twice and record the measured times in Table 1 in the report.
- Determine the oscillation period of one pendulum when both pendulums are deflected in the same sense and by the same distance. To do this measure the time required for 10 oscillations; repeat the measurement twice. Record the measured values in Table 2 in the report.
- Determine the oscillation period of one pendulum, when the two pendulums are deflected in opposite senses and by equal amounts. To do this measure the time required for 10 oscillations; repeat the measurement twice. Record the measured values in Table 3 in the report.

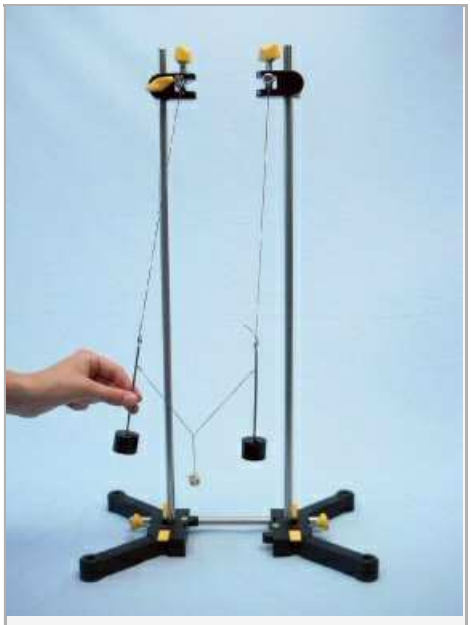


Fig. 6

Report: Coupled pendulum systems

Results – Observations

How do the two pendulums react after initiation?

.....

.....

.....

.....

Results – Table 1

Record the measured values for the beat period T_s in Table 1 and calculate the average value of the pendulum's beat period T_s and its beat frequency f_s.

Measurement No.	T_s in s	Average T_s in s	f_s in Hz
1	1		
2	1	1	1
3	1		

Evaluation – Table 1

Record the measured values for the beat period T_1 in table 1, when both pendulums are deflected in the same sense .

Calculate the average value of the pendulum's beat period T_1 and its beat frequency f_1.

Measurement No.	t_{10} in s	Average t_{10} in s	T_1 in s	f_1 in Hz
1	1			
2	1	1	1	1
3	1			

Evaluation – Table 2

Record the measured values for the beat period T_2 in table 2 when the two pendulums are deflected in opposite senses.

Calculate the average value of the pendulum's beat period T_2 and its beat frequency f_2.

Measurement No.	t_{10} in s	Average t_{10} in s	T_2 in s	f_2 in Hz
1	1			
2	1	1	1	1
3	1			

Robert-Bosch-Breite 10
D - 37079 Göttingen
Tel: +49 551 604 - 0
Fax: +49 551 604 - 107
info@phywe.de
www.phywe.com

Evaluation – Question 1

An oscillating pendulum has oscillation energy in the form of potential and kinetic energy. Can you explain the processes observed on the coupled pendulum with the aid of energy considerations?

.....

.....

.....

.....

Evaluation – Question 2

Determine the difference of the oscillation frequencies for excitation in the same and opposite directions f_2 - f_1:

.....

.....

.....

.....

Evaluation – Question 3

Compare the result with the beat frequency f_s. What do you notice?

.....

.....

.....

.....

Evaluation – Additional Task 1a

Does the strength of coupling (position of attachment and the mass) between the two pendulums influence the beat frequency?

.....

.....

.....

.....

Robert-Bosch-Breite 10
D - 37079 Göttingen

Tel: +49 551 604 - 0
Fax: +49 551 604 - 107

info@phywe.de
www.phywe.com

Evaluation – Additional Task 2

To check this establish the beat frequency, when you

- change the attachment location
- reduce the coupling mass

Summarize your observations:

.....

.....

.....

.....