5.8 Coupled pendulum systems

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.

Use the space below for your own notes.

Material

Material from "TESS advanced Physics Set Mechanics 1, ME-1" (Order No. 15271-88)

Position No.	Material	Order No.	Quantity
1	Support base, variable	02001-00	1
2	Support rod with hole, stainless steel, 100 mm	02036-01	2
2	Support rod, stainless steel 18/8, *l* = 250 mm, *d* = 10 mm	02031-00	1
2	Support rod, split in 2 rods, *l* = 600 mm	02035-00	2
3	Bosshead	02043-00	2
4	Weight holder for slotted weights, 10 g	02204-00	2
5	Slotted weight, black coloured, 10 g	02205-01	2
5	Slotted weight, black coloured, 50 g	02206-01	2
6	Set of precision weights, 1g...50g, in case	44017-00	1
7	Stop watch, digital, 24h, 1/100 s and 1 s	24025-00	1
7	Measuring tape, *l* = 2 m	09936-00	1
7	Fish line, in reel, *d* = 0.7 mm, 20 m 02089-00	02089-00	140 cm
Additional Material			
	Scissors		1

Material required for the experiment

Setup

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).

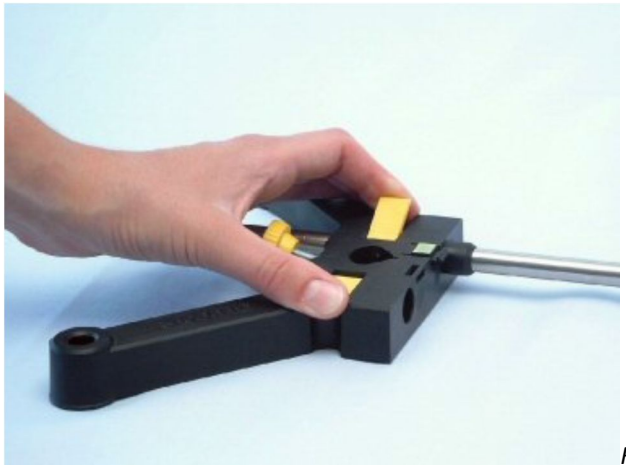

Fig. 1

Fig. 2

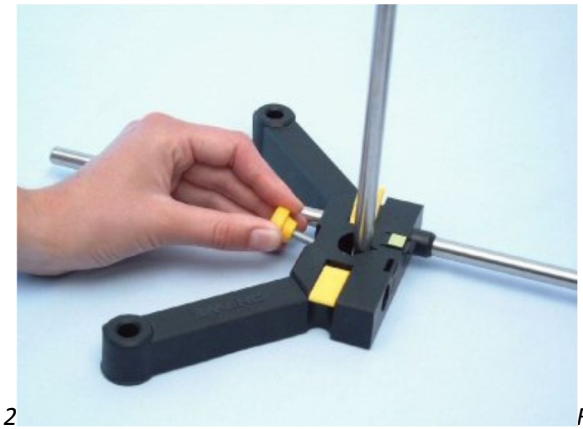

Fig. 2

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

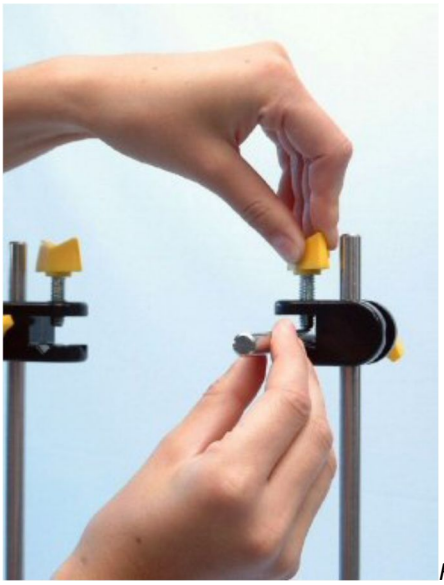

Fig. 4

- 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).

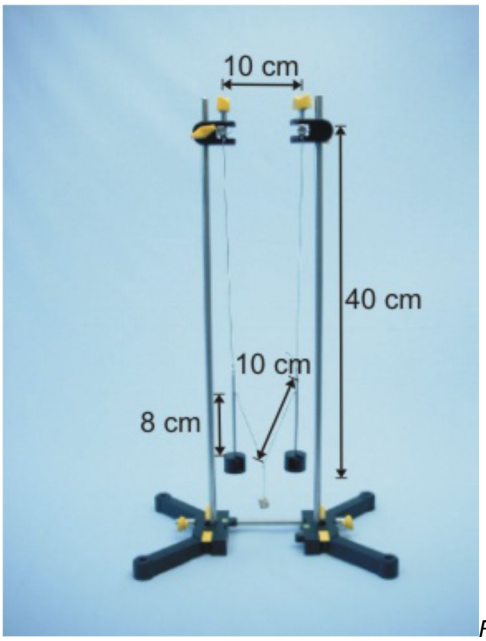

Fig. 5

Action

- 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 to the Results page.
- 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 on the Results page.
- 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 on the Results page.
- 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 on the Results page.

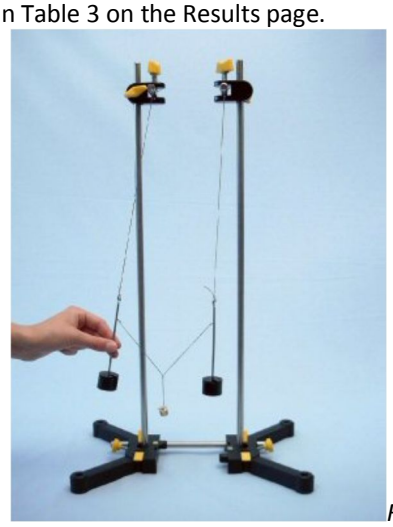
Fig. 6

Results

Result 1

How do the two pendulums react after initiation?

Table 1

Beat period T_s

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

Table 2

Oscillation period T_1 with excitation in the same direction

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

Table 3

Oscillation period T_2 with excitation in opposite directions

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

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?

Question 2:

Using the measured values in Table 1 on the Results page, calculate the average value of the pendulum's beat period T_s and its beat frequency f_s.

Question 3:

Using the measured values in Tables 2 and 3 on the Results page, calculate the average values of the pendulums' beat periods (T_1, T_2) and their beat frequencies (f_1, f_2) for excitation in the same (1) and opposite senses (2). Add these values to the tables.

Question 4:

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

Question 5:

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

Additional Task

Question 1a:

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

Question 1b:

To check this establish the beat frequency, when you

- change the attachment location
- reduce the coupling mass

Summarize your observations: