5.2 Simple pendulum (mathematical pendulum)

Task

What influence do mass and pendulum length have on the oscillation period of a thread pendulum?

Measure the oscillation period of a thread pendulum with various masses and pendulum length.
Calculate the length of a "second pendulum".

Use the space below for your own notes.

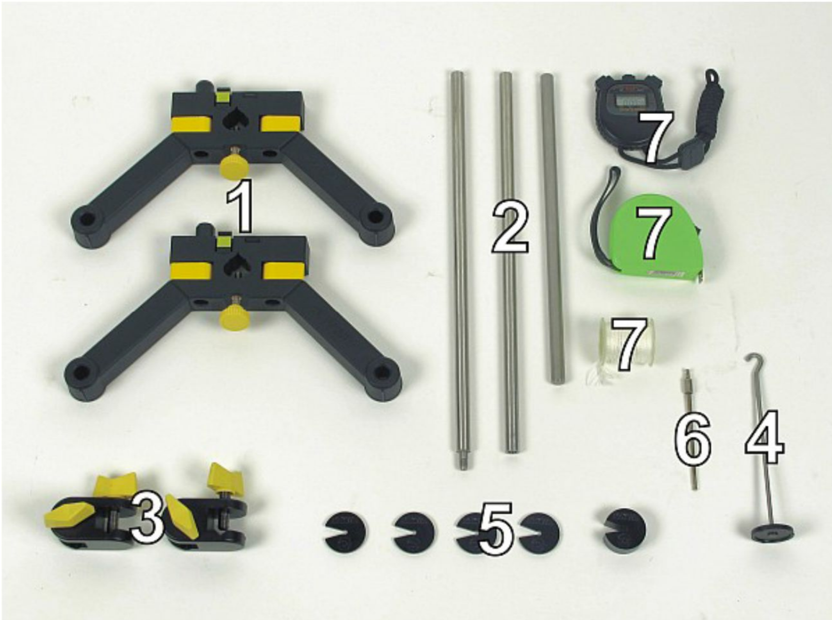
Material

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, 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	1
3	Bosshead	02043-00	2
4	Weight holder for slotted weights, 10 g	02204-00	1
5	Slotted weight, black coloured, 10 g	02205-01	4

5	Slotted weight, black coloured, 50 g	02206-01	1
6	Holding pin	03949-00	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	80 cm

Material required for the experiment



Setup

First screw the split support rod together (Fig. 1). Connect the two halves of the support base with the 25 cm support rod and tighten the locking levers (Fig. 2). Set the 60 cm support rod into the support base, tighten it with the locking screw (Fig. 3).

Fig. 1


Fig. 2

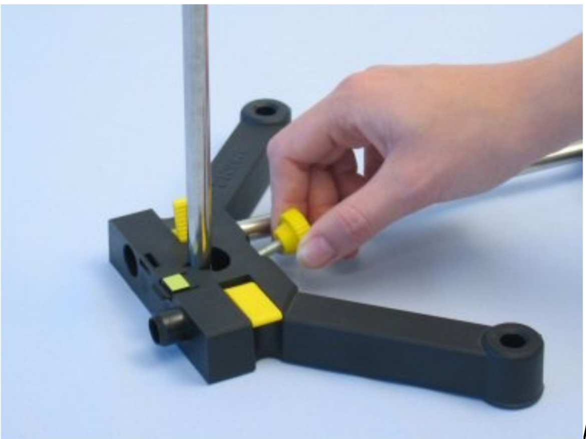


Fig. 3

Attach the bosshead to the 60 cm support rod and fix the holding pin in the bosshead (Fig. 4).


Fig. 4

Tie a piece of fish line (ca. 80 cm) to the hook of the weight holder (Fig. 5) and pull the second end of the fish line through the hole in the holding pin (Fig. 6).

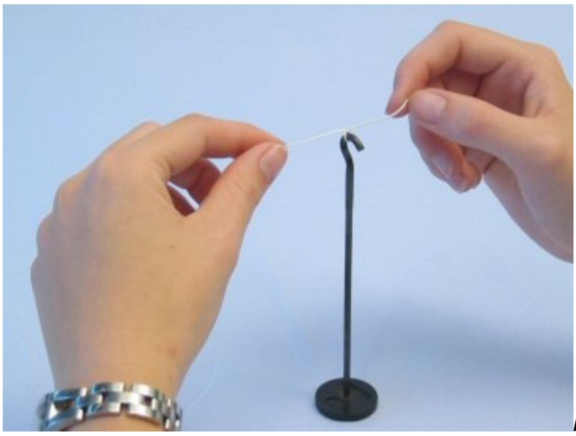


Fig. 5

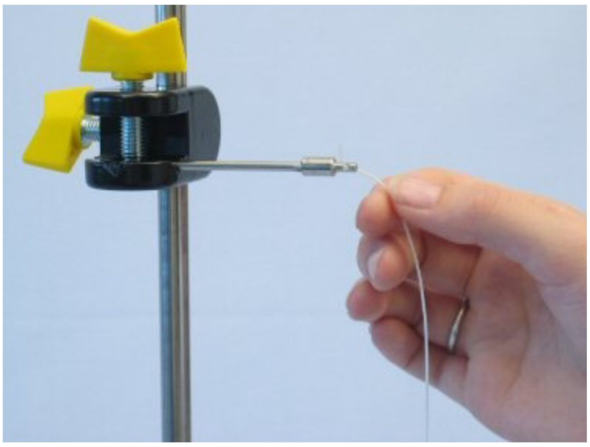


Fig. 6

Clamp the second bosshead to the support rod and tie the fish line to it (Fig. 7). Place enough slotted weights on the weight holder so that the total mass is 50 g and hang the weight holder to the second end of the fish line. For hanging the slotted weight up the weight holder, you should slip the slotted weight over the top of the weight holder (Fig. 8).

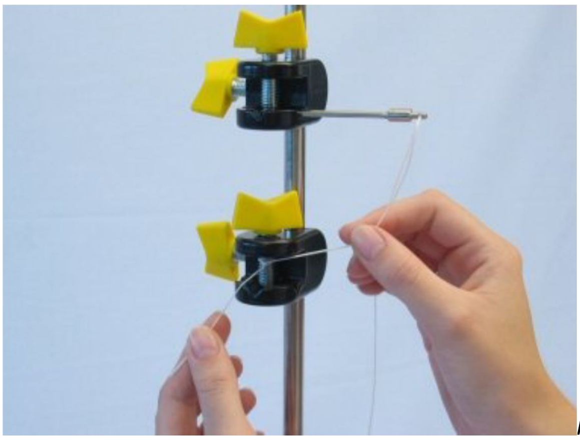


Fig. 7


Fig. 8

Shift the lower bosshead so that the total length from the upper support point to the middle of the weights is as close as possible to 60 cm (Fig. 9).

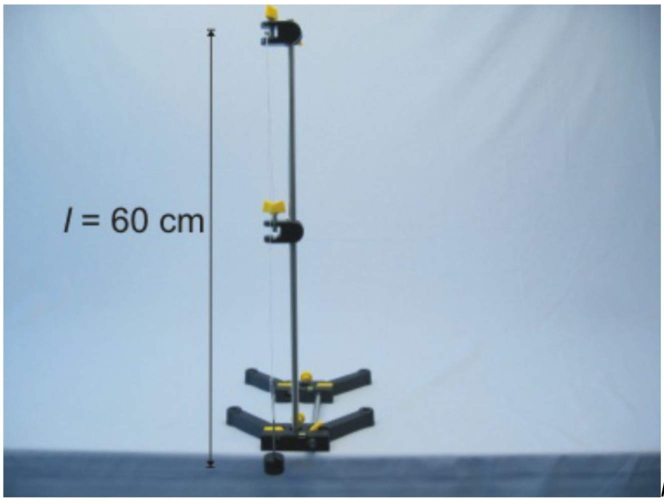


Fig. 9

Action

Move the end of the pendulum about 20 cm laterally and release it carefully (Fig. 10).

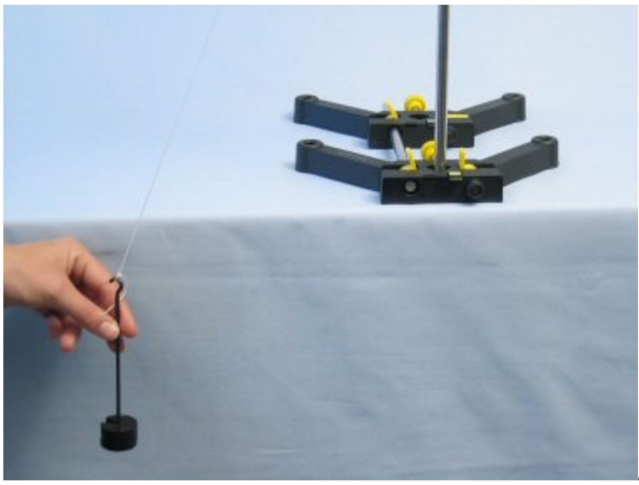


Fig. 10

- Determine the time required for 10 oscillations of the pendulum with a total mass of *m* = 50 g and then *m* = 100 g.
- Record the results in Table 1 on the Results page.
- Place slotted weights on the weight holder until the total mass is 50 g.
- Measure the time required for 10 oscillations at pendulum lengths of 5, 10, 20, 30, 40 and 50 cm. (At 5 and 10 cm tie a 50 g mass piece on the fish line, i.e. without the weight holder.)
- Record the measuring results in Table 2 on the Results page.

Results

Table 1

l = 60 cm; $\sqrt{l} =$ ________ $\sqrt{cm}$

***m* in g**	***t* in s**	***T in s***
50		
100		

Table 2

m = 50 g

***l* in cm**	**√(*l*) in √(cm)**	***t* in s**	***T in s***
50			
40			
30			
20			
10			
5			

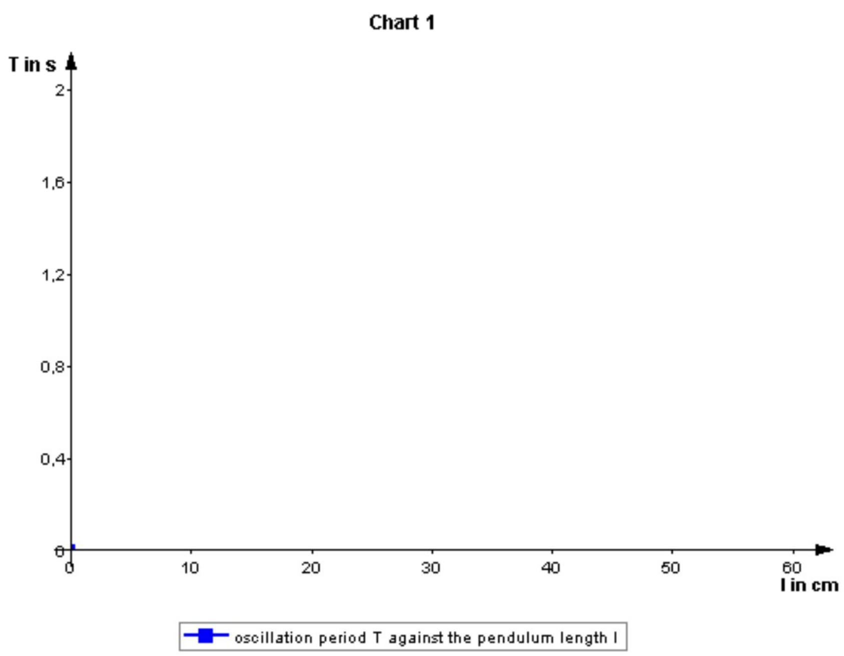
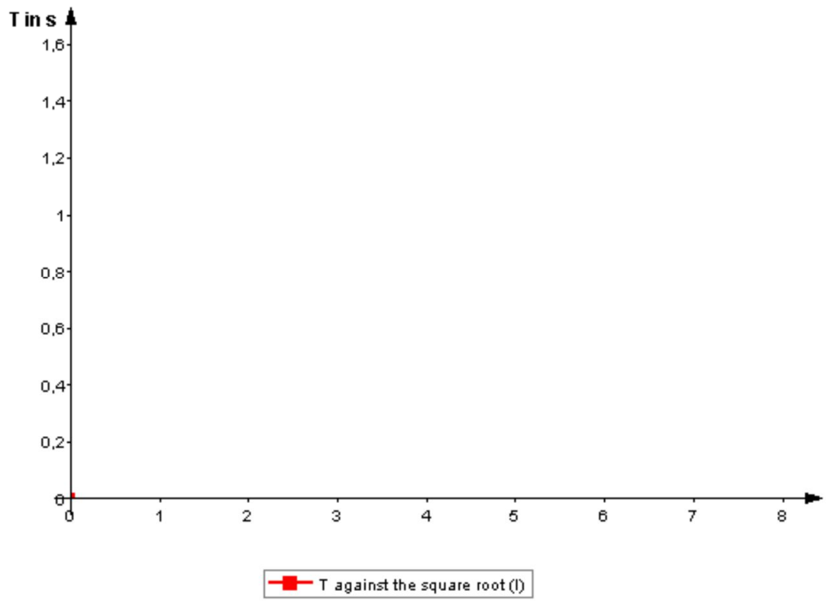


Chart 2



Evaluation

Question 1:
Calculate the oscillation period *T* for one oscillation from the time *t* for 10 oscillations. Add the results to the tables on the Results page.

Question 2:
Is the oscillation period a function of the mass?

Question 3:
Watch Chart 1 on the Results page, the blue graph will show the oscillation period *T* against the pendulum length *l*. What is the effect of the pendulum length on the oscillation period?

Question 4:
Calculate the square root of the pendulum length and record the results in Table 2 on the Results page. Watch the Chart 2 on the Results page. The red graph will show you $T = f(\sqrt{l})$.

What does the resulting curve look like?

Choose the right proportionality.

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

Question 5:

Calculate the proportionality factor *K* from the diagram and compare it with the value which you obtain when you divide 2 π by the square root of the acceleration of gravity *g*:

$$K' = \frac{2\pi}{\sqrt{g}}$$

Is K = K'?

What are the dimensions of *K*?

- O $s/\sqrt{cm}$
- O s/cm
- O $\sqrt{cm}\,/s$

Question 6:

Using the given and calculated quantities, set up the oscillation equation for the thread pendulum:
Which is the right formula?

- O $K' = \sqrt{2\pi}\,\frac{l}{g}$
- O $K' = 2\pi\sqrt{\frac{g}{l}}$
- O $K' = 2\pi\sqrt{\frac{l}{g}}$

Express this in words.

Question 7:

Calculate the pendulum length for a thread pendulum that has an oscillation period of 2 s (second pendulum, since the time for half an oscillation = 1 s):

l = ______ cm.

Supplementary problem

Calculate the acceleration of gravity g from your measured data using the proportionality factor determined in Question 5:

$g = (2\pi/K)^2$

g = ______ cm/s^2.