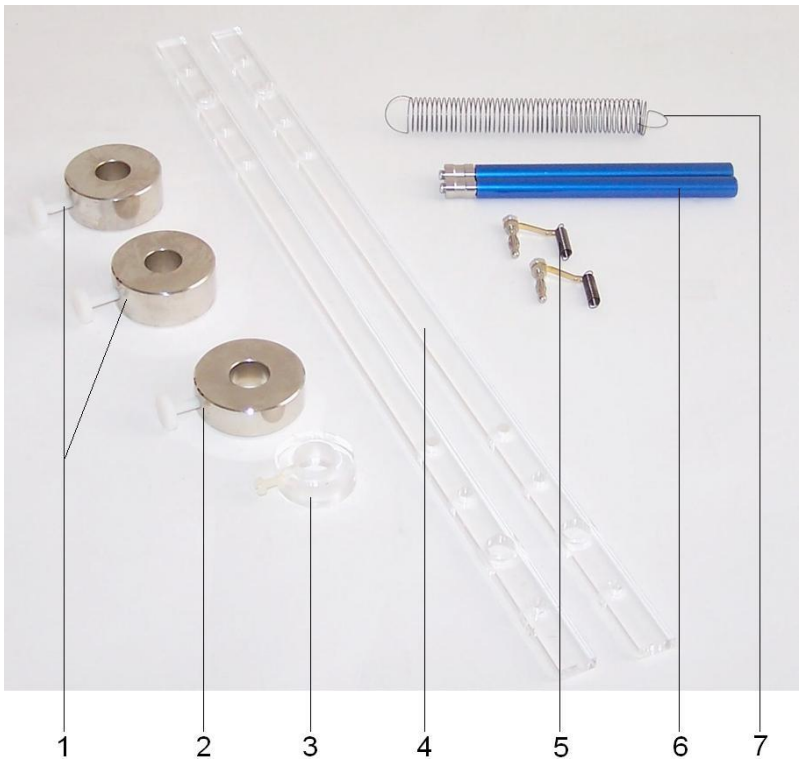
Supplementary Kit “Physical Pendulum” 1012853

Instruction manual

10/16 TL/ALF



1 Weight, 200 g
2 Weight, 150 g
3 Acrylic ring
4 Pendulum rod
5 Coupling spring
6 Bearing rod
7 Tension spring

1. Description

The Supplementary Kit “Physical Pendulum” is designed for assembly of a physical pendulum with a movable bob, a double coupled pendulum, a reversible (Kater) pendulum or a metronome pendulum in a space-saving table-top experiment set-up.

It consists of pendulum rods, bearing rods and weights for constructing the pendulums themselves, as well as additional components for attaching them to the dynamic force sensors from the set Sensors “Mechanical Oscillations” in order to record and extensively analyse the oscillations with the help of an oscilloscope.

2. Equipment

2 Pendulum rods
2 Bearing rods
2 Weights, 200 g
1 Weight, 150 g
1 Acrylic ring
1 Tension spring
2 Coupling springs

3. Technical data

Pendulum rods

Length:	450 mm
Weight:	45 g
Separation of bearing holes :	330 mm
Material:	Transparent acrylic

Weights

Weights:	2x 200 g approx. 1x 150 g approx.
Acrylic ring:	10 g approx.

Tension springs

Spring constant:	2.5 N/m

4. Set-up of pendulums without sensors

4.1 General information

The following additional equipment is necessary in order to carry out the experiments:

1 Stand Equipment “Mechanical Oscillations” 1012849

1 Digital stopwatch 1002811

A stopwatch can provide sufficiently accurate results as long as at least 10 periods are measured.

- Make sure the stand rods are firmly fitted into the base and that all other mounting elements are also firmly fitted to the stands.
- Do not bend the pendulum rods over the bearings (otherwise they could break).

4.2 Set-up for a physical pendulum without sensors

- Screw a stand rod with both external and internal threads into the central threaded sockets of the base plate and extend the rod by screwing one with external thread only onto the end.
- Slip a double clamp onto the rod.
- Insert a bearing rod into the double clamp and slot the pendulum rod over the bearing.

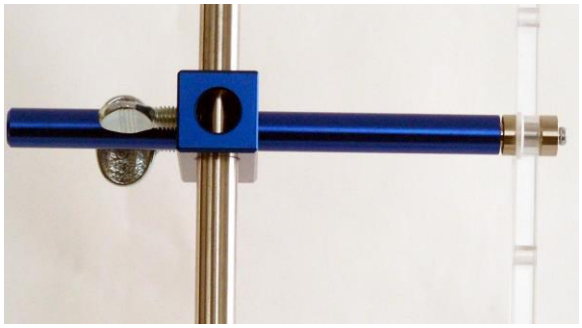


Fig. 1 Set-up of pendulum rods

- Attach a 200-g weight (pendulum bob) to the pendulum rod with the knurled screw.

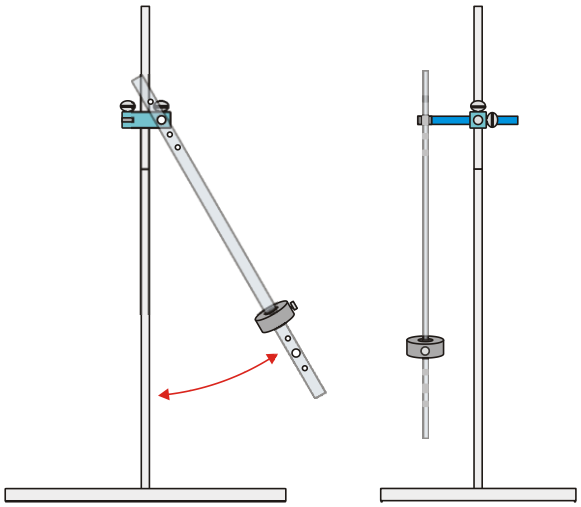


Fig. 2 Set-up for physical pendulum without sensors

4.3 Set-up for a double pendulum without sensors

- Screw the stand rods with both external and internal threads into the outer threaded sockets of the base plate.
- Extend both rods by screwing rods with external thread only onto the ends of them.
- Attach double clamps near the top of both stand rods and turn them to point inwards so that the slots are vertical and facing one another.
- Clamp the cross bar into the slots of the two double clamps.
- Insert bearing rods into the double clamps and slot pendulum rods over the bearings.
- Couple the pendulum rods together with a tension spring.
- Attach 200-g weights (pendulum bobs) to the pendulum rods with the knurled screws.

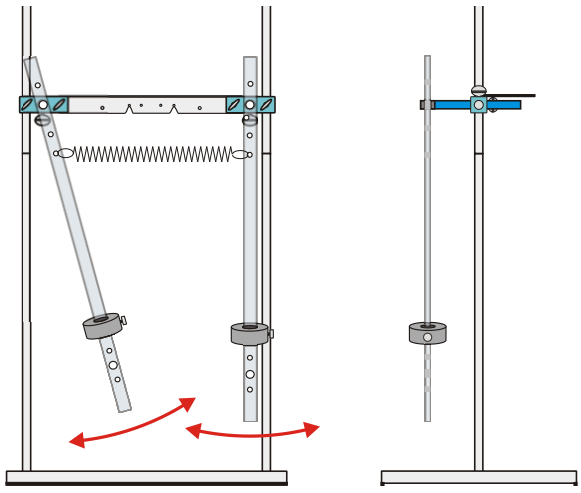


Fig. 3 Set-up for coupled pendulum without sensors

4.4 Set-up for a reversible (Kater) pendulum

- Set up the pendulum stand as described in 4.2.
- To set up a reversible pendulum, position a 200-g weight between the bearing holes and a 150-g weight at the top end of the pendulum.

Note:

- Only deflect the pendulum by small angles.

If the bearing holes are $l = 330$ mm apart, as long as the pendulum is correctly adjusted, the oscillation about either bearing should have a period $T = 1.152$ s ($g = 9.81$ m/s²).

$$T = \sqrt{\frac{4\pi^2 \cdot l}{g}}$$

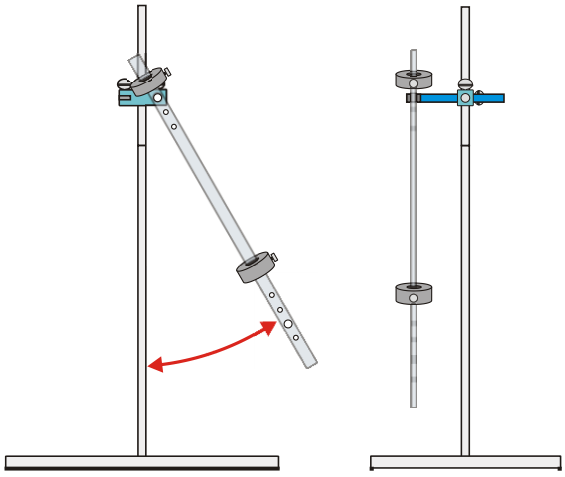


Fig. 4 Set-up for reversible pendulum

4.5 Set-up for metronome pendulum

- Set up the pendulum stand as described in 4.2.
- Attach a 200-g weight at the bottom of the pendulum rod with the knurled screw.
- Attach the acrylic ring near the top of the pendulum.

Note: This pendulum can be used to achieve a wide variety of periods.

By moving the large weight, the oscillating system can be adjusted to approach an indifferent equilibrium. Period durations are then effectively limited only by friction at the bearings.

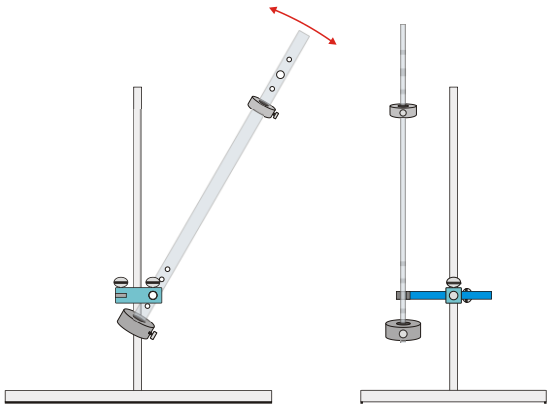


Fig. 5 Set-up for a metronome pendulum

5. Set-up for pendulums with sensors

5.1 General information

The following additional equipment is necessary in order to carry out the experiments:

1 Stand Equipment “Mechanical Oscillations” 1012849

1 Sensors “Mechanical Oscillations”
@230V 1012850
or
@115V 1012851

1 USB oscilloscope 2x 50 MHz 1017264
1 PC, operating system Win XP, Vista, Win 7

or

1 Analogue oscilloscope 2x 30 MHz 1002727

Caution: Dynamic force sensors must not be subjected to mechanical overloading

- Neither sensor hook may be loaded with more than 5N in the axial direction and 1 N in transverse direction.
- Be especially careful with the maximum loading force when assembling the system or suspending loops or springs from the hook.
- Make sure stand rods are firmly fitted into the base and that all other mounting elements are also firmly fitted to the stands.
- Do not bend the pendulum rods over the bearings (otherwise they could break).

The force sensors can be set up with high or low pre-tensioning of the coupling springs (by attaching them to two different positions on the cross bar). This means that the distance between pendulum rod and force sensor may differ. One position allows for high amplitudes with long pendulum swings, whereas the other provides for low bearing friction but only short pendulum swings and therefore small amplitudes are possible.

5.2 Set-up for coupled pendulum with sensors

- Set up the pendulum stand as described in 4.3.
- Attach a force sensor to the cross bar with the knurled screw.
- Stretch a coupling spring between the pendulum rod and the force sensor.
- Clamp the bearing rod into the double clamp in such a way that the coupling springs and pendulum rod move in roughly the same plane as the hook of the force sensor.
- Set up the second force sensor in the same way.
- Couple the two pendulum rods together with the tension spring.
- Connect the force sensors to the inputs for channels A and B of the MEC amplifier board.
- Connect the outputs to an oscilloscope and start the experiment.

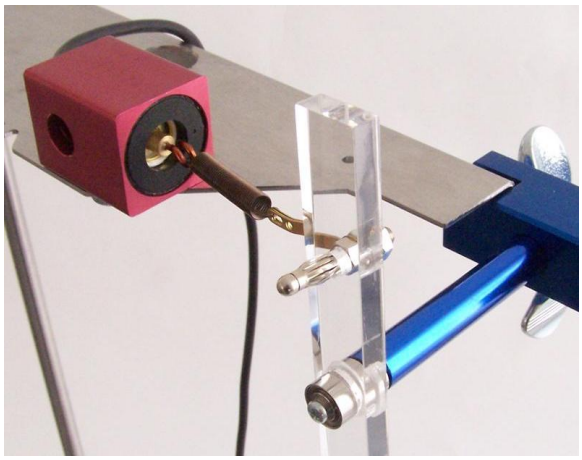


Fig. 6 Coupling of force sensor

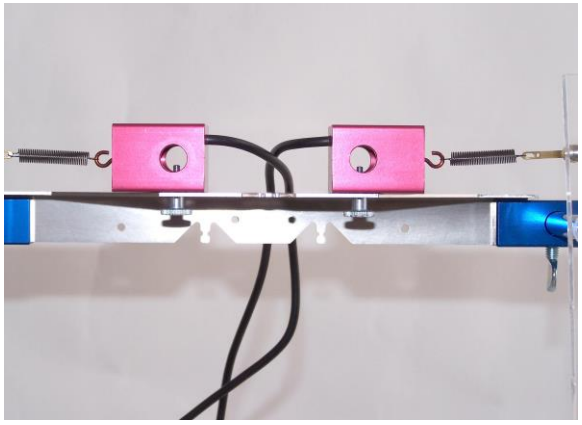


Fig. 7 Set up of force sensors

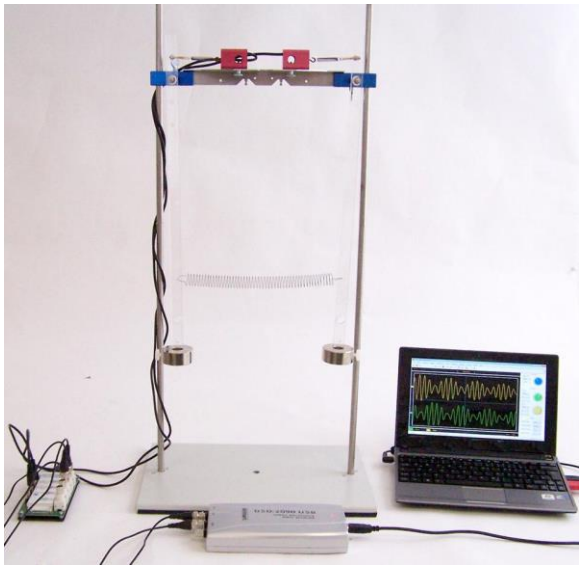


Fig. 8 Set-up for coupled pendulum with sensors and USB oscilloscope

6. Disposal

- Packaging and components should be disposed of, where necessary, at local recycling centres.