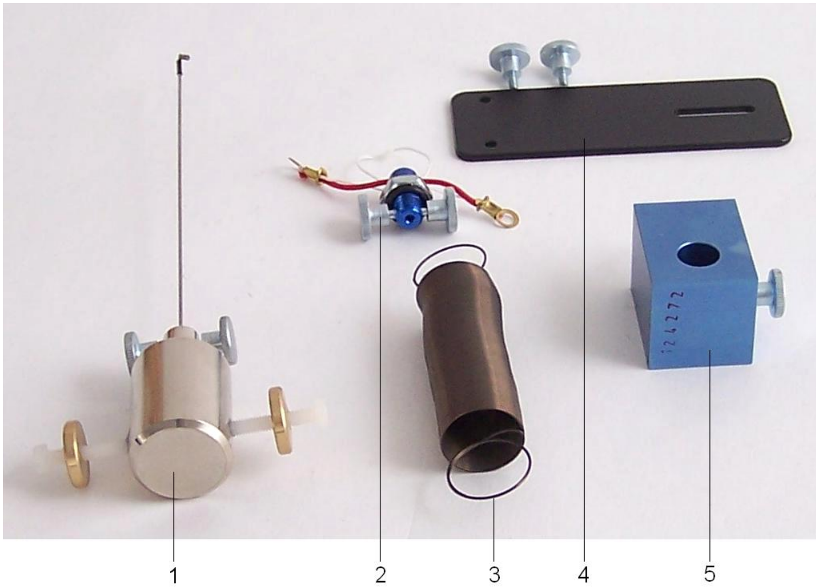
Supplementary Kit "Wilberforce Pendulum" 1012844

Instruction manual

10/16 TL/ALF



1 Rotating body with wire hook
2 Spring module
3 Coil spring
4 Vertical plate and knurled screws
5 Body with hook

Description

The Supplementary Kit "Wilberforce Pendulum" has everything you need to build a Wilberforce pendulum in a space-saving table-top set-up.

It consists of a coil spring and an adjustable rotating body, allowing the moment of inertia to be fine-tuned in order to investigate coupled translation and rotation forces by means of the Wilberforce experiment.

A spring module makes it possible to connect the pendulum to the dynamic force sensors from the Sensors "Mechanical Oscillations" set in order to record and analyse oscillations with two degrees of freedom by means of an oscilloscope.

The wire hook is designed to stabilise the axial rotation motion and guarantees non-slip coupling of the rotating body to the spring.

2. Contents

1 Coil spring
1 Rotating body
1 Wire hook
1 Vertical plate
1 Body with hook
1 Spring module

3. Technical data

Spring constant for coil spring:	5 N/m
Mass of rotating body:	142 g

4. Set-up

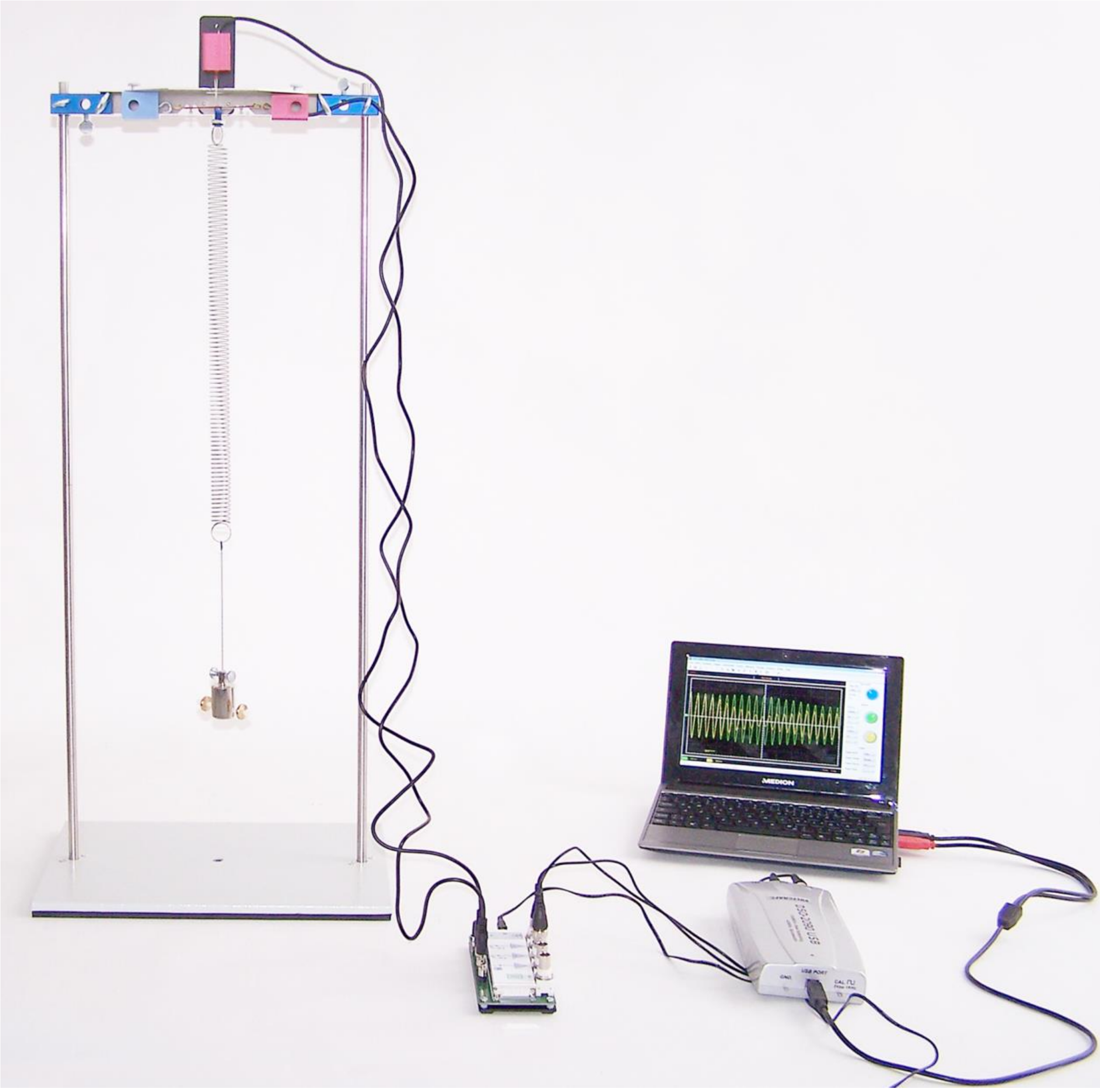


Fig. 1 Set-up for Wilberforce pendulum with USB oscilloscope

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

5. Operation

5.1 General information

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

- Neither dynamometer 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.

5.2 Set-up for Wilberforce pendulum

- 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.
- Remove the knurled screws from the spring module and hook the spring onto the mount. Tighten the nut with the rubber ring by hand against the spring eyelet (the eyelet must not have any play in the spring module).

Fig. 2 Spring module with coil spring

- Lay the body with hook on the cross bar and loosely attach it from underneath with the knurled screw. Refer to fig. 3.
- Hook one of the eyelets of the spring module onto the body with hook.
- Put the dynamometer on the cross bar and attach the second eyelet of the module to the hook on the dynamometer.
- Carefully attach the dynamometer to the cross bar with the knurled screw in the same way as the body with hook. Make sure that the red band is taut and straight.

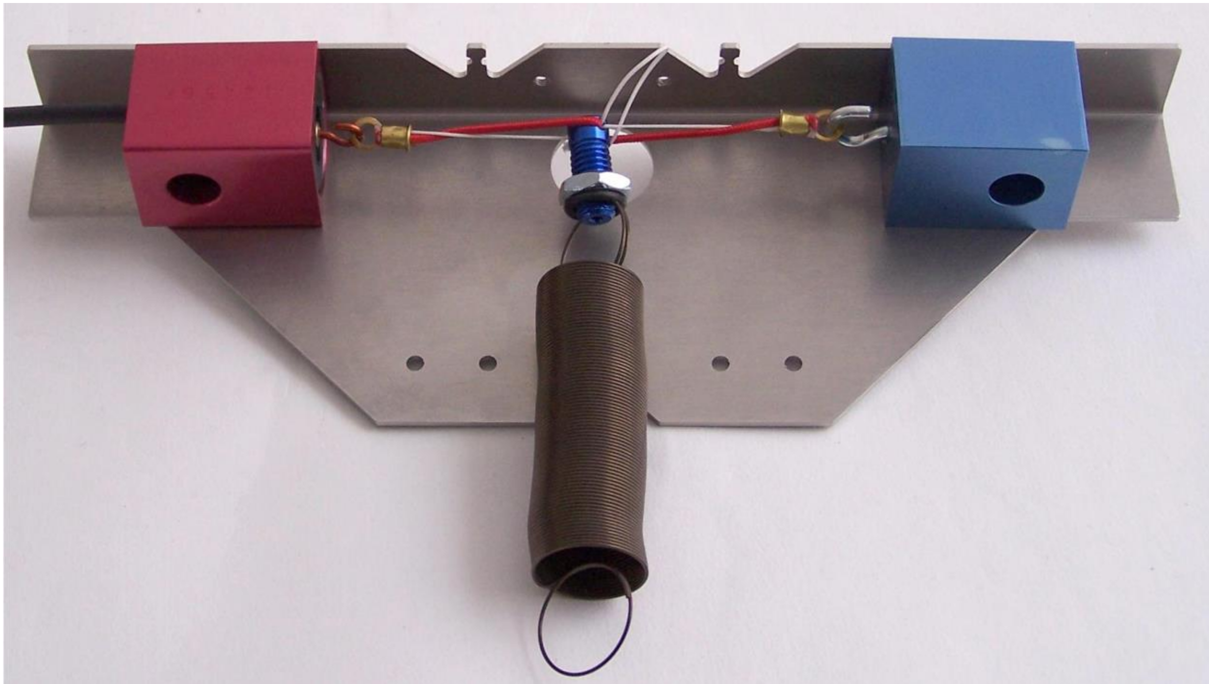


Fig. 3 Assembly of spring module

Fig. 4 Set-up of cross bar between stands

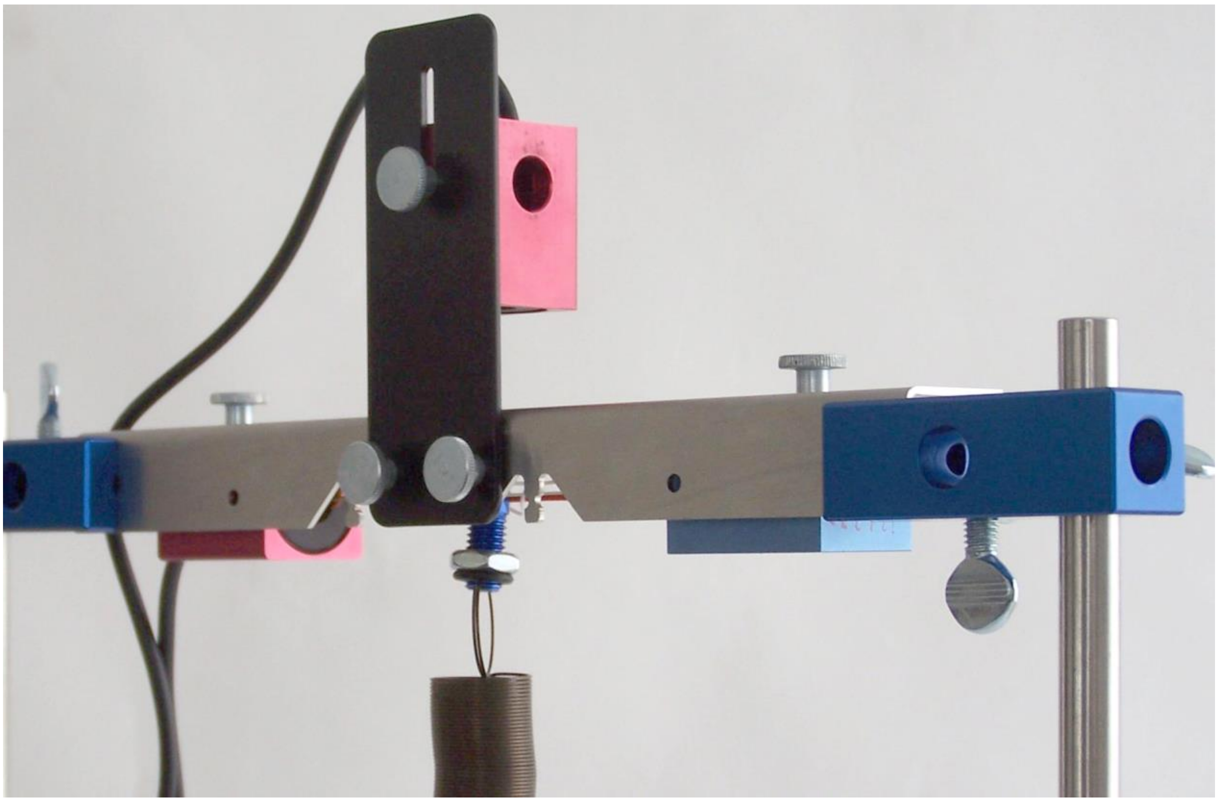


Fig. 5 Set-up of vertical sensor

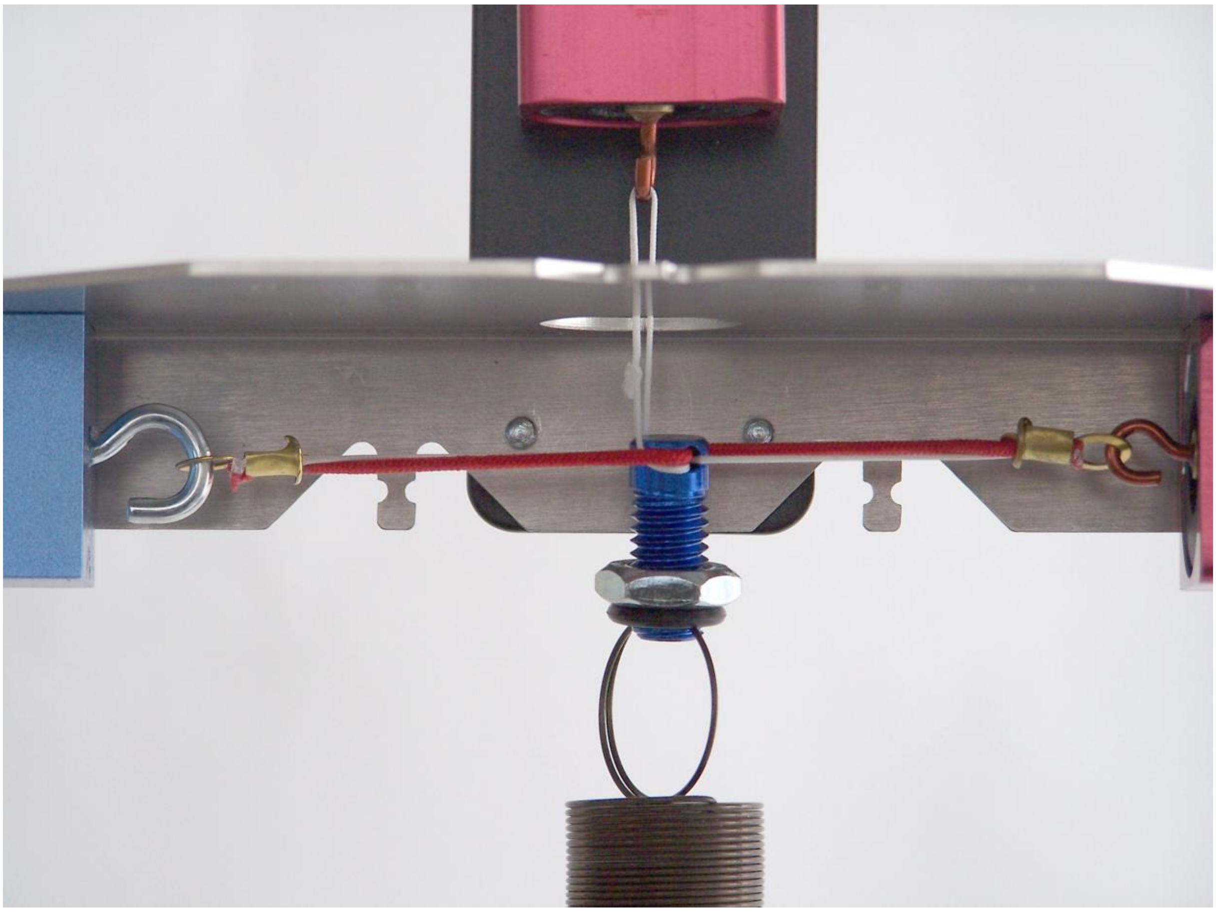


Fig. 6 Full set-up for module

- Attach the cross bar into the slots of the two clamps. Refer to fig. 4.
- Screw the second force sensor to the lowest position on the vertical plate and attach it to the cross bar. Refer to fig. 5.
- Suspend the loop of thread on the spring module from the hook of the vertical force sensor and loosen the knurled screw enough to push the sensor upward till the loop is gently tautened (the red cord of the spring module needs to still run in a straight line between the two hooks). Refer to fig. 6.
- Suspend the wire hook from the lower eyelet of the spring and hang the rotating body from the end of it.
- 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.

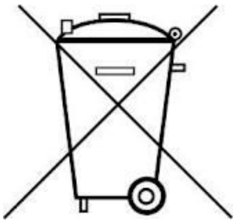
Note:

- In order to initiate an oscillation which is as free as possible from disturbance, pull the rotating body vertically down onto the base plate and then release it.

The two calibrating weights on the rotating body (knurled screws) need to be screwed in by an equal amount. For a well calibrated pendulum, the rotary and translational motions should have identical periods. The amplitudes of both types of oscillation pass through the point of zero amplitude in quick succession.

6. Disposal

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



7. Functioning principle

The Wilberforce pendulum demonstrates coupling between translation and rotation oscillations in a calibrated mass-spring system.

The cause of the coupling between the two oscillations lies in the geometry of the spring. A motion along the length of the spring causes the wire of the coil to twist, which initiates rotary oscillation. The rotation similarly gives rise to extension or contraction of the spring, leading to further oscillation along its length.

For the up and down motion, the frequency of the pendulum is influenced by both the spring constant and the mass of the rotating body. The period and motion of the rotary oscillation are determined by the torsional constant of the spring and the adjustable moment of inertia of the rotating body.

The resonant frequency of the translation oscillation can be calculated using Equation 1:

$$\omega_{\mathrm{trans}} = \sqrt{\frac{k}{m}} \qquad (1)$$

k = Spring constant
m = Mass

The resonant frequency of the rotary motion is determined as follows:

$$\omega_{\mathrm{rot}} = \sqrt{\frac{K}{J}} \qquad (2)$$

K = Torsion constant
J = Moment of inertia of rotating body