Kater's Reversible Pendulum 1018466

Instruction manual

09/16 TL/DU

1 Pendulum
2 Stand
3 Floor cover

1. Safety instructions

When carefully assembled and properly used, safety of experimenting with the reversible pendulum can be guaranteed. There is, however, a possible risk of injury or damage to the pendulum if care is not taken.

- Read this instruction manual all the way through and observe it in full.
- Set up the stand on solid, level ground and fasten the assembly screws tightly.
- Fasten the securing screw for the movable pendulum bob tightly so that the bob can not move unchecked.
- Use the adjustment screws in the base plate of the stand to align the bearing plate in such a way that the bearing axes of the pendulum bob can be even.
- Always handle the pendulum with both hands when setting it up or adjusting it.
- Carefully suspend the pendulum from the bearing plate and check that the bearing axes are in the correct positions.
- Do not subject the pendulum to excessive pushes and do not deflect it by more than 10 cm at the bottom end.

2. Components

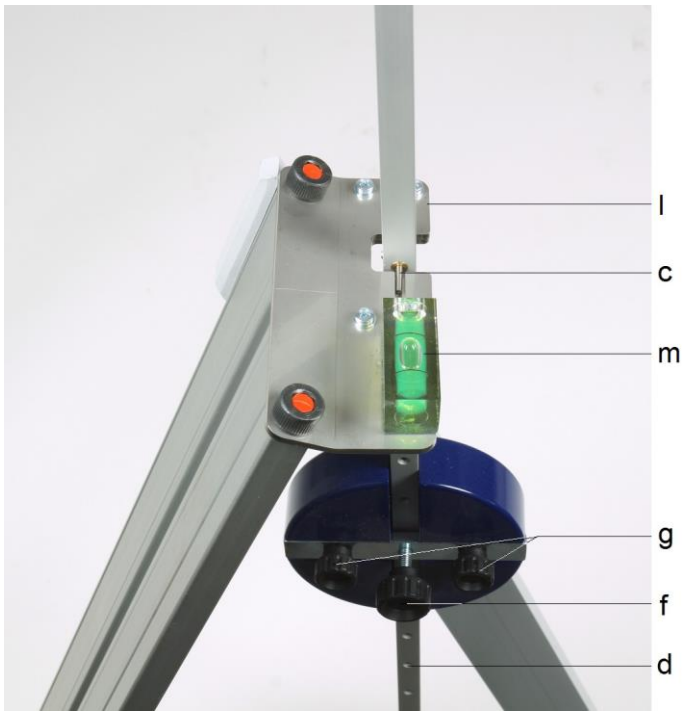
Pendulum

a Fixed pendulum bob
b Pendulum rod
c Bearing fulcrum
d Latch-in positions
e Movable pendulum bob
f Securing screw
g Assembly screws

Stand

h Stand board
i Positioning screws
j Stand rod
k Stand board
l Bearing plate
m Spirit level

n Floor cover



3. Description

The reversible pendulum is a physical pendulum with two bearing fulcra plus one fixed and one movable pendulum bob. It oscillates in its stand either with a period of oscillation T_1 about the first bearing fulcrum or period T_2 about the second fulcrum. By shifting the movable pendulum bob it is possible to adjust both these periods until they are equal. The pendulum then has a reduced length equal to the distance *d* between the bearing axes and the following equation applies:

$T_1 = T_2 = 2\pi \cdot \sqrt{\frac{d}{g}}$, *g*: acceleration due to gravity

When it is moved, the movable weight latches into place every 2.5 cm. For finer movements the bob can be turned by 180° about the vertical and mounted that way round.

4. Technical data

Period of calibrated pendulum (calculated assuming g = 9.81 m/s^2):	1794 ms
Overall dimensions:	80x125x30cm^3
Overall weight:	6.3 kg approx.
Length of pendulum rod:	120 cm
Separation between bearing fulcra:	80 cm
Fixed pendulum bob:	1.4 kg approx.
Movable pendulum bob:	1.0 kg approx.
Pendulum deflection	max. 10 cm

5. Set-up

5.1 Choice of set-up location

If the floor on which the equipment is set is springy, then the oscillation energy is transferred to the whole stand and measurement errors can then arise.

- Only set up and use the reversible pendulum on solid, level ground.

On smooth, slippery or sensitive surfaces:

- Put a mat under the base plate and the strut of the stand.

5.2 Assembly of stand

- Undo the screw (see Fig. 1), fold out the stand rod.
- Secure it in its operating position with a moderate degree of torque.

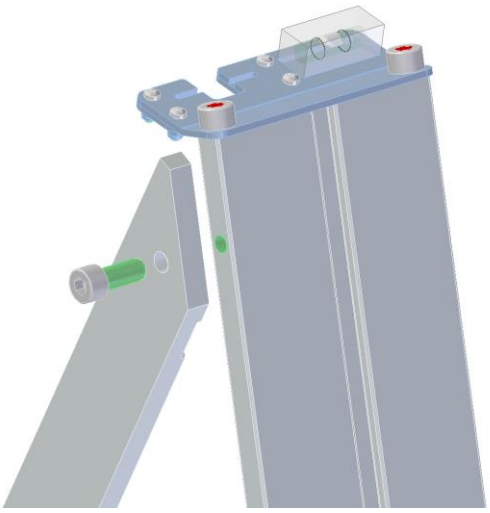


Fig. 1: Attachment of stand rod to stand board

5.3 Vertical positioning of the pendulum rod

- Grip the pendulum with both hands and carefully suspend it from the bearing plate (see Fig. 2).
- The vertical positioning of the pendulum rod should be adjusted using the positioning screws in such a way that the bubble of the spirit level is centered (see Fig. 3).

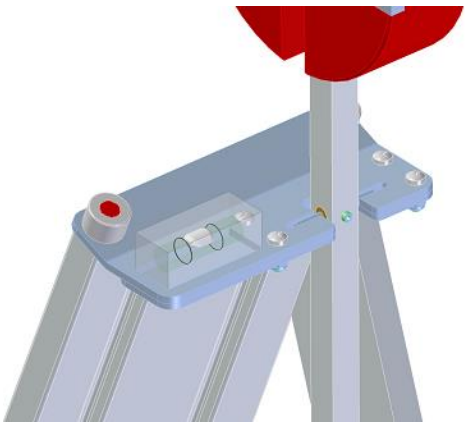


Fig. 2: Bearing plate with pendulum rod suspended

Fig. 3: Setting position with the help of the spirit level

6. Operation

6.1 Moving the pendulum rod

- Use gentle pressure to move the pendulum in the direction of the arrow with several pushes at the position marked until the deflection is about 5 cm.

Note: Larger deflections can lead to non-negligible measurement errors.

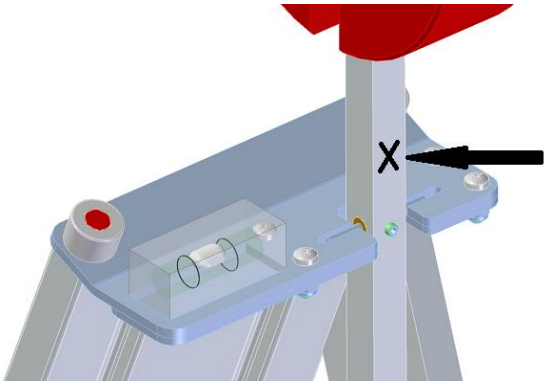


Fig. 4: Moving the pendulum rod

6.2 Reversing the pendulum position

- Use both hands to lift the pendulum out of the bearing plate and turn it around.
- Carefully suspend the pendulum from the bearing plate by its other fulcrum. Then carry on as in step 6.1.

6.3 Period of oscillation depending on the position of the movable pendulum bob

Fig. 5: Experiment set-up with light barrier and digital counter

Additionally required:

1 Light barrier	1000563
1 Digital counter (@230 V)	1001033
or	
1 Digital counter (@115 V)	1001032

- Set up the light barrier under the pendulum rod while it is stationary and connect the barrier to the digital counter (see Fig. 5).
- Suspend the pendulum rod from the bearing plate in such a way that both the fixed bob (red) and the movable bob (blue) are below their corresponding fulcra.
- Attach the movable bob in the wedge-shaped groove nearest to the fixed bob, i.e. the lowest one. This position will subsequently be referred to as measuring point 1 (even when the pendulum rod is suspended above the other fulcrum).
- Measure the period of oscillation and make a note of it..
- Keep moving the movable bob from one groove to the next and secure it (measuring points 2 – 13). In each case, measure the period of oscillation and make a note of it.

- Now suspend the pendulum rod from the bearing plate in such a way that the fixed pendulum bob (red) is above the relevant fulcrum and the movable bob (blue) is below its bearing.
- Secure the movable pendulum bob in the wedge-shaped groove nearest to the fixed bob, i.e. the highest one. This position will subsequently be referred to as measuring point 1 (see above).
- Measure the period of oscillation and make a note of it..
- Keep moving the movable bob from one groove to the next and secure it (measuring points 2 – 13). In each case, measure the period of oscillation and make a note of it.

- Plot a graph of the periods of oscillation determined in both sets of measurements as a function of the numbers n of the measurements (see Fig. 6).

6.4 Determination of acceleration due to gravity

The periods of oscillation T_1 and. T_2 are identical at the two points where the curves intersect and at these points they are equal to the period of oscillation T_0 of the calibrated pendulum, i.e. $T_0 = T_1 = T_2$.

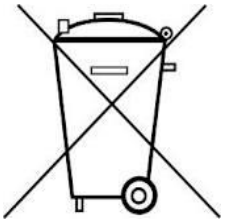
From the period duration T_0 measured in step 6.3 for a calibrated reversible pendulum and a distance l = 0.8 m between the two fulcra, corresponding to the shortened pendulum length, it is possible to determine the acceleration due to earth's gravity:

$$g = 4 \cdot \pi^2 \cdot \frac{l}{T_0^2} .$$

Note: To adjust the pendulum so that both periods of oscillation are exactly the same, it may be necessary to turn the pendulum bob by 180° about the vertical and mount it on the pendulum rod that way round.

7. Storage, cleaning, and disposal

- Keep the apparatus in a clean, dry, dust-free place.
- Do not use aggressive cleaning agents or solvents to clean the apparatus.
- In order to clean the equipment, use a soft, damp cloth.
- The packaging should be disposed of at local recycling centres
- If the equipment itself is to be disposed of, it must not be included with normal household waste. Local regulations are to be obeyed.



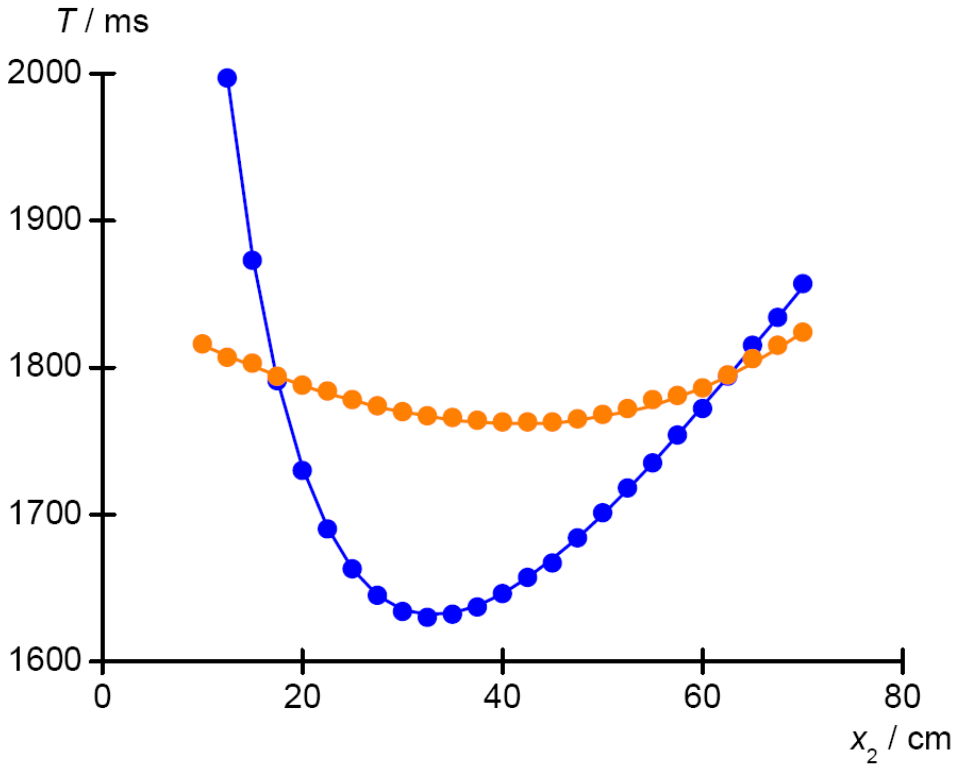


Fig. 6: Period of oscillation T as a function of measuring point number n. Red circles: Both pendulum bobs below fulcrum. Black squares: Fixed pendulum bob above fulcrum, movable bob below