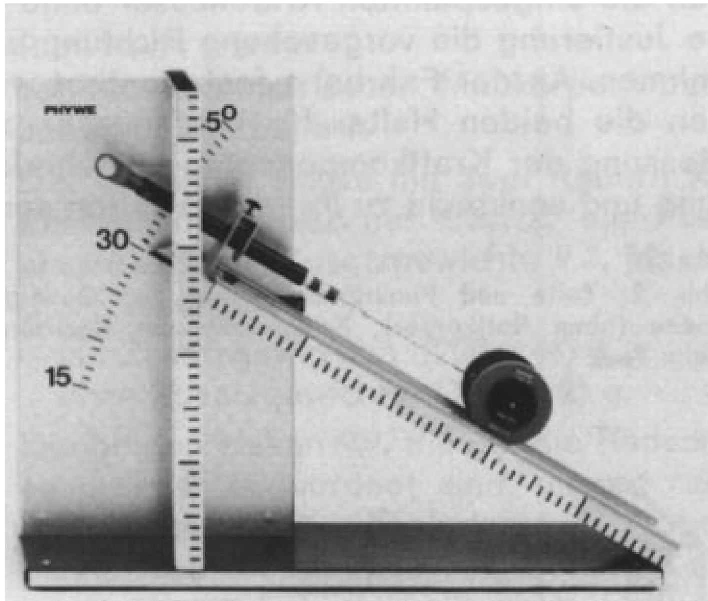
Inclined plane with roller

11301.00
11301.88

Operating Instructions



1 PURPOSE AND CHARACTERISTIC FEATURES

This compact piece of equipment enable the forces which hold a body in equilibrium on an inclined plane to be investigated at various angles of inclination, without the need for time-consuming assembly and tedious adjustments. Oblique-angled components can be investigated in addition to the important special case of right-angled force components. Further to this, the fundamental relationship between force, distance of travel, vertical travel and work for simple machines can be worked out. The balance of forces on a wedge can also be examined on a model basis.

The use of a roller as measuring object has the advantage that the lines of all forces working on it intersect at a single point, its centre of gravity. This not only avoids unwanted torques, but also allows the physical facts to be demonstrated more simply and clearly.

The inclined plane is equipped with two rules and an angular scale. The angular scale allows a direct reading of the actual setting of the continuously adjustable angle of inclination of the plane α. The two rules allow direct readings of the height and length of the track, whose quotient gives sin α, the relevant angle function for the inclined plane.

Easily mounted, practical holders enable spring balances for the determination of the force components to be fixed so that they take up the appropriate position when the angle of inclination is changed, without any need of additional adjustment.

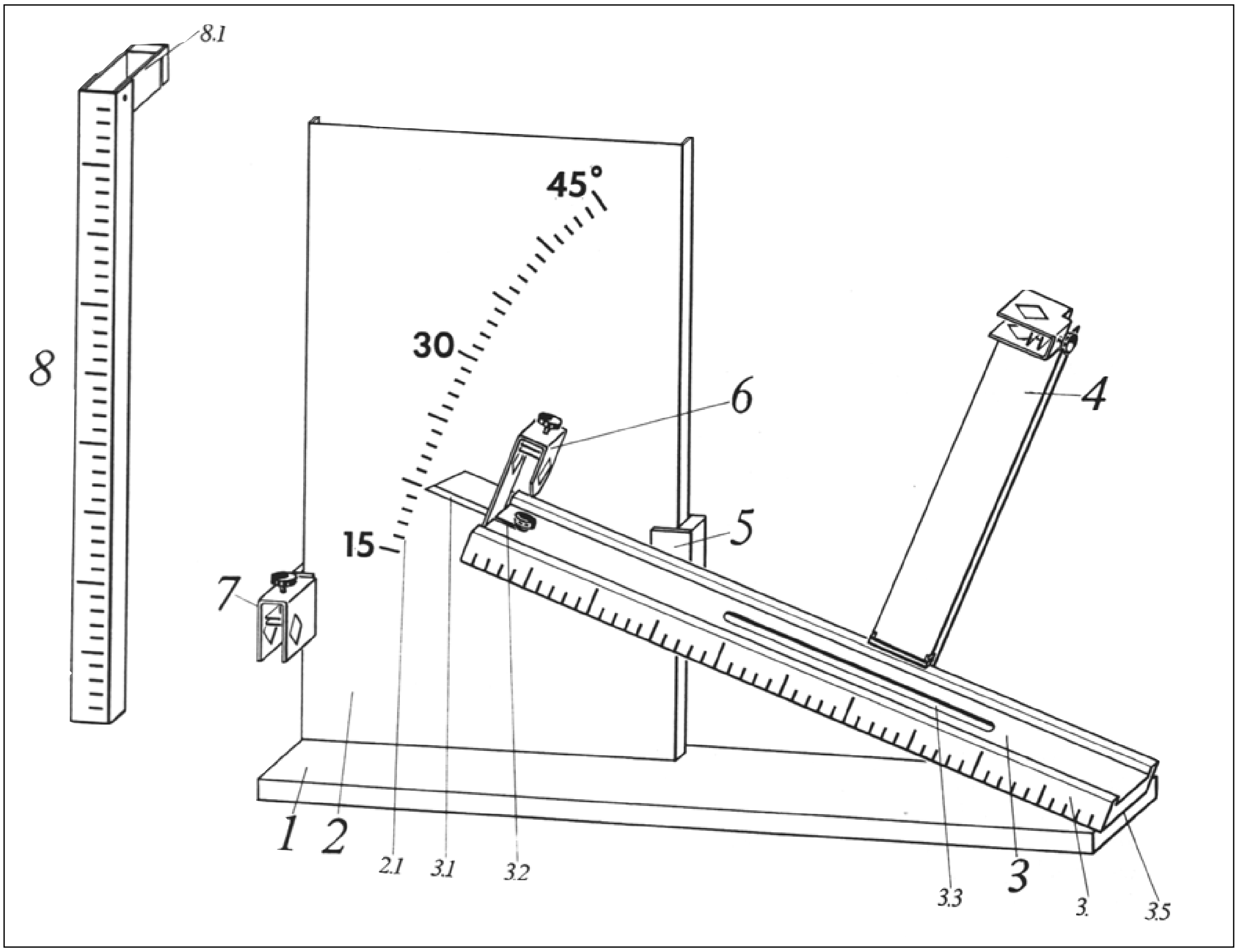


Fig. 2

2 FUNCTION ELEMENTS AND OPERATING ELEMENTS

The inclined plane has the following function and operating elements (see Fig. 2, 3 and 4).

1 Base plate

2 Vertical plate with angular scale *2.1*. Two milled screws on the back serve to fix it to the base plate.

3 Inclinable track with cm rule which serves as the inclined plane. The hinge *3.5* allows the track to be freely swivelled up, and the pin of the track positioner *5* holds it in position. The pointer *3.1* shows the angle of inclination on the scale *2.1*. The screw hole *3.2* accepts the milled screw of the spring balance holder *6*. Fishing line can be threaded through the aperture *3.3* to connect the roller *9* to a spring balance held in holder *7*.

4 Holder for a spring balance for measurement of the force component perpendicular (normal) to the track. The shaft guide *4.1* enables the holder to be slid lengthways along the track, and its milled screw to fix it in position. The milled screw of the tension bearing *4.2* holds the spring balance in position.

5 >Adjustable track positioner for changing the angle of inclination. The pin *5.1* on the shaft guide *5* holds the inclinable track. The guide rail *5.2* allows the shaft guide to be slid up and down the right-hand side of the vertical plate (this shaft guide is self-clamping).

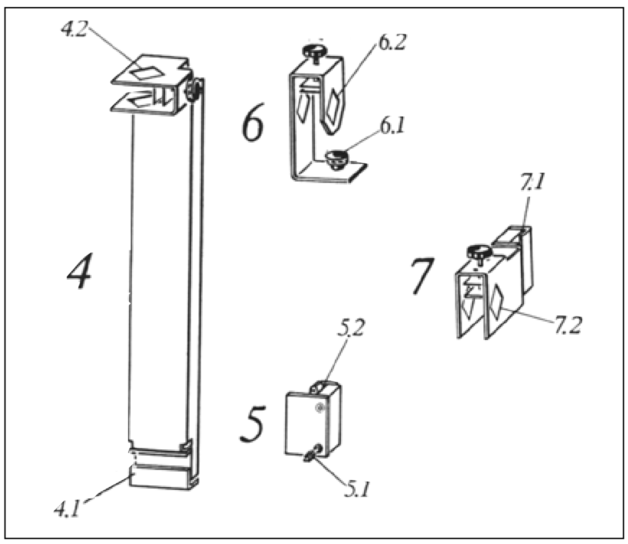


Fig. 3

6 Holder for a spring balance for measurement of the force component along the track. The milled screw *6.1* fits in the screw hole *3.2* to enable the holder to be fixed in position. The tension bearing *6.2* ensures the positioning of the spring balance parallel to the track.

7 Holder for a spring balance for measurement of the horizontal force component. The shaft guide *7.1* enables the holder to be slid up and down the left-hand side of the vertical plate, and its milled screw to fix it in position. The tension bearing 7*.2* ensures the horizontal positioning of the spring balance.

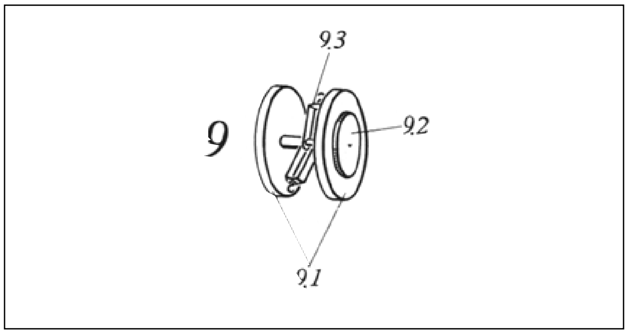


Fig. 4

8 Vertical rule. The swing-arm *8.1* with slit and milled screw enables it to be fitted on the top edge of the vertical plate.

9 Roller with two wheels *9.1* and a pair of supplementary weights *9.2* which can be screwed off or on. The two hooks *9.3* are rotable around the axle of the wheels and serve to hold thread connections to spring balances. In this way, the lines of action of all forces always pass through the centre of gravity of the roller.

3 HANDLING

The inclined plate can be disassembled if required, e.g. to save storage space. Reassemble it as follows:

- Swivel up the inclinable track, position the vertical plate with its lower edge tight against the base plate and tighten the milled screws on the back of it.
- Fit the track positioner *5* over and down the right-hand side of the vertical plate, and lower the inclinable track onto pin *5.1*.
- Fix the holder for a spring balance *6* in the aperture *3.3*.
- Fix the vertical rule *8* with swing-arm *8.1* on the top edge of the vertical plate.
  According to requirements, the holders *4* and *7* must also be fitted on as follows:
- For measurement of components perpendicular to the track, slide holder *4* from the right along the back edge of the track and fix it in position.
- For measurement of the horizontal force component, slide holder *7* from the top down the left-hand side of the vertical plate and fix it in position.

Stand the inclined plane on a horizontal surface. A thread connection (fishing line) is recommended for connection of the spring balances. Suitable lengths are as follows:

- Holder *4* (component normal to the track): approx. 2 cm
- Holder *6* (component along the track): approx. 10 cm
- Holder *7* (horizontal component): approx. 25 cm

Spring balances for 1 N and 2.5 N are suitable for measuring the force components. Their zero position must be checked, and corrected if necessary, prior to use in the experiment. To eliminate errors due to friction, tap them lightly before reading reading them. When the height is to measured, press the vertical rule *8* tight against the inclined track and move it in the hinge until it is vertical. Measure the height of the the lower edge of the track from the foot of the vertical rule.

4 EXPERIMENTS

4.1 Measurement of the track component F_s (down-incline force)

First determine the weight force *F* of the roller with and without supplementary weights (2 N spring balance). Then insert the spring balance in holder *6* and connect it with thread to the roller positioned on the track (1 N spring balance for the roller without supplementary weights, 2.5 N spring balance for the roller with supplementary weights). Determine the component F_s for various angles of inclination and heights *h*, so that the relationship

$$F_s = F \cdot \sin\alpha \quad bzw. \quad F_s = F \cdot \frac{h}{l} \quad l = \text{track length}$$

can be verified, possibly also by plotting a graph.

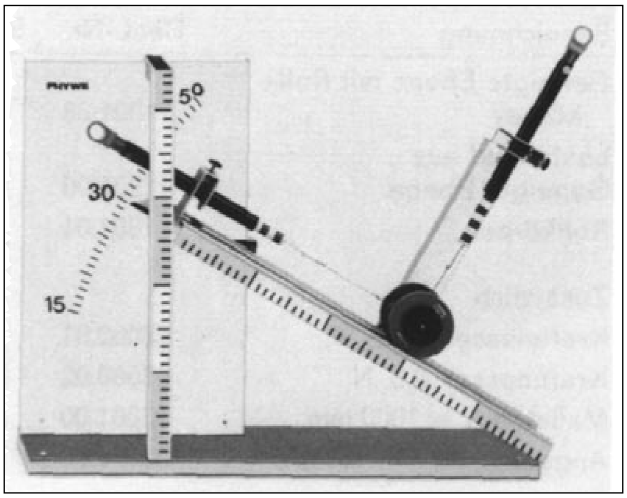


Fig. 5

4.2 Decomposition of the weight force of a body on an inclined plane (down-incline force F_s and normal force F_n)

The experimental set-up is shown in Fig. 5. A 2.5 N spring balance must be additionally used here. Insert it in holder *4* and position it along the track at the location of the roller axle. Connect it to the second hook on the roller with thread. Shift the spring balance so far up in the holder that the roller only just does not lie on the track. Also ensure that the direction of action of the lifting force is exactly perpendicular to the track. When the adjustment is correctly made, the force component F_s will have the same value as found for the corresponding angle of inclination of the plane in the case with the roller lying on the track (Experiment 4.1). The relationship;

$$F_n = F \cdot \cos\alpha \quad bzw. \quad F_n = F \cdot \frac{x}{l}$$

in which *x* is the projection of the track length *l* to the horizontal, can now be verified for various angles of inclination and heights *h* of the roller with and without supplementary weights.
As in this case the roller is held in equilibrium by two forces which are perpendicular to each other, the experiment also decomposes the weight force *F* into two right-angled components, whose direction varies with change in the angle of inclination.

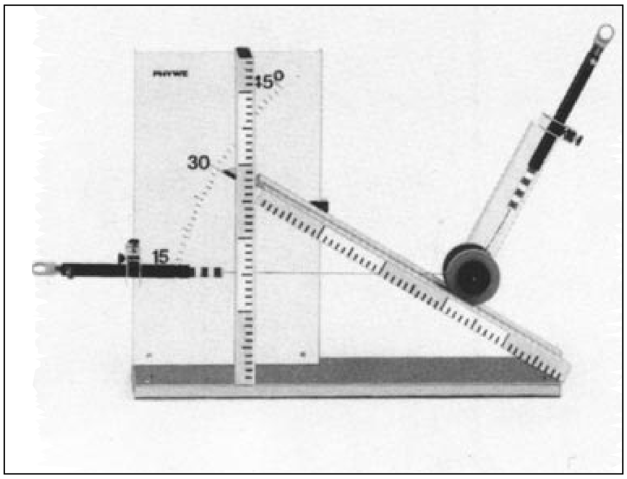


Fig. 6

4.3 Decomposition of the force into oblique-angled components F_x and F_n*
(model experiment for a wedge)

The experimental set-up is shown in Fig. 6. The direction of the lifting force is changed here from along the track to the horizontal. In this way, the weight force *F* is decomposed into two components at an oblique angle to each other, the horizontal component F_x and the normal component F_n^*. Ensure that the roller is somewhat above the lower end of the aperture in the inclined plane, so that the horizontal connecting thread passes frictionless through the aperture. Again carry out the experiment at various angles of inclination and heights *h* of the roller with and without supplementary weights, so that the following relationship can be verified:

$$F_x = F \cdot \tan\alpha = F \cdot \frac{h}{x} \quad ;$$

$$F_n^* = \frac{F}{\cos\alpha} = F \cdot \frac{l}{x}$$

$$\frac{F_x}{F_n^*} = \sin\alpha = \frac{h}{l}$$

here again, *x* is the projection of the track length *l* to the horizontal
The force equilibrium determined in this experiment is in principle the same as that in a wedge.

5. SPECIFICATIONS

Base plate	(600 x 136) mm
Vertical plate	(270 x 440 mm
Scale range	15° - 45°
Track length	500 mm
Mass of roller	100 g ± 2%
Mass of supplementary weights	100 g ± 2%

6 LIST OF EQUIPMENT

Inlined plane with roller		11301.88
consisting of		
Inclined plane, compact device		11301.00
Roller for inclined plane		11301.01
accessories additionally required		
Spring balance, 1 N	(2x)	03060.01
Spring balance, 2.5 N	(2x)	03060.02
Fish line, *l* = 100 m		02090.00

7 NOTE ON THE GUARANTEE

We guarantee the instrument supplied by us for a period of 6 months. This guarantee does not cover natural wear nor damage resulting from improper handling.
The manufacturer can only be held responsible for the function and safety characteristics of the instrument, when maintenance, repairs and changes to the instrument are only carried out by the manufacturer or by personnel who have been explicitly authorized by him to do so.