Resolution of forces on an inclined plane (Item No.: P1252500)

Curricular Relevance

Area of Expertise: Physik
Education Level: Klasse 7-10
Topic: Mechanik
Subtopic: Kräfte, einfache Maschinen
Experiment: Kräftezerlegung an der geneigten Ebene

Difficulty	Preparation Time	Execution Time	Recommended Group Size
Intermediate	10 Minutes	20 Minutes	1 Student

Additional Requirements:

Experiment Variations:

Keywords:

Principle and equipment

Principle

Demonstrate that the weight of a body on an inclined plane can be resolved into two components which are perpendicular to each other and one of which acts in the direction of the slope.
Additionally, investigate how the force acting down the plane can be calculated.

Equipment

Position No.	Material	Order No.	Quantity
1	Demo Physics board with stand	02150-00	1
2	Torsion dynamometer	03069-03	2
3	Inclined plane f.demonstr.board	02152-00	1
4	Scale for demonstration board	02153-00	1
5	Optical disk, magnet held	08270-09	1
6	Roller for inclined plane	11301-01	1
7	Marker, black	46402-01	1

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Set-up and procedure

Set-up

- Place the protractor disk onto the demonstration board in such a manner that the intended vertical line (the zero degree line) is vertical.
- Draw a horizontal line on the demonstration board with the white board pen, e.g. as shown in Fig. 1.
- Place the inclined plane onto the protractor disk such that it forms an angle α = 15° with the horizontal line and touches the previously drawn horizontal line with its lower end.
- Locate the two dynamometers at positions similar to those indicated in Fig. 1 and adjust them.

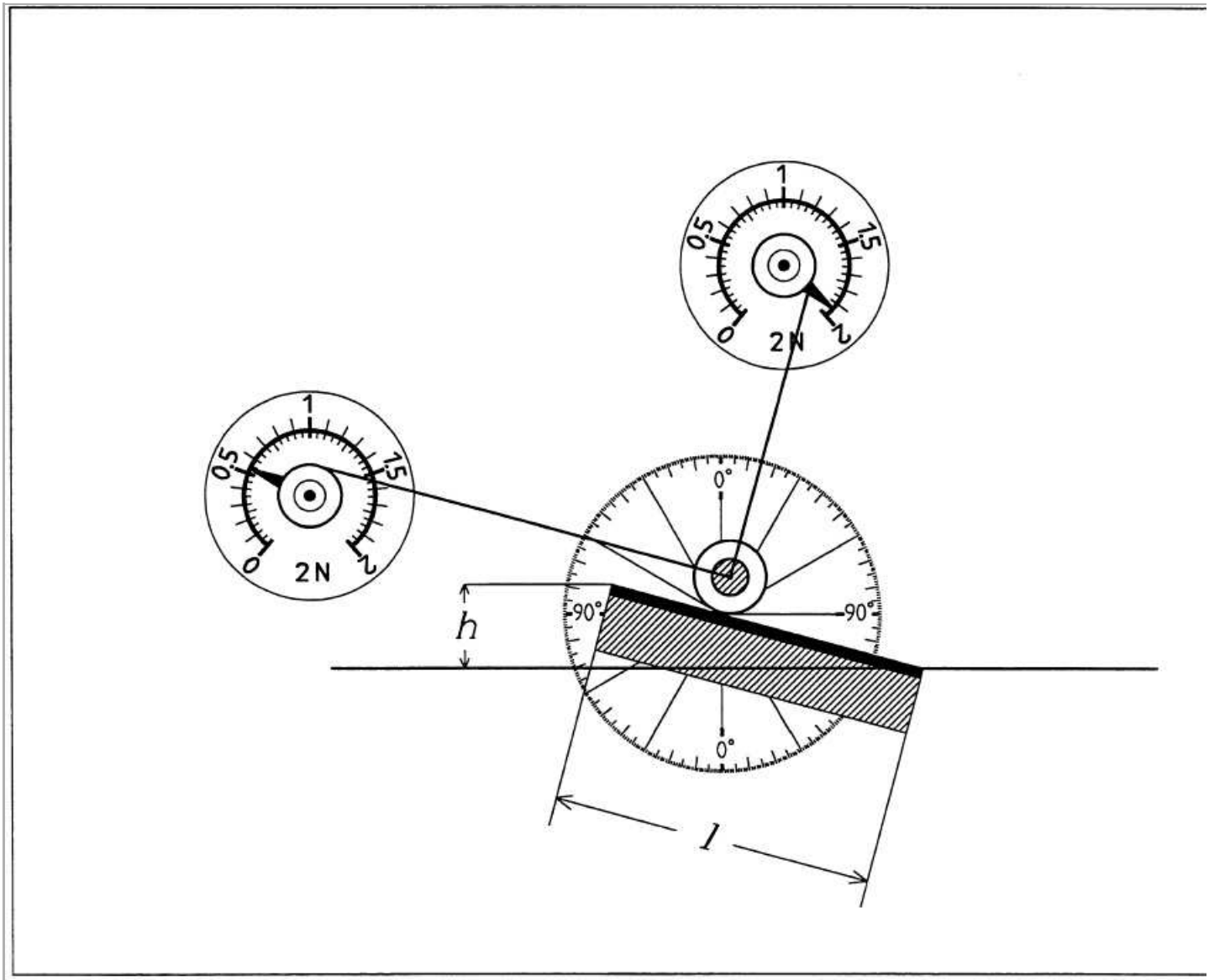

Fig. 1

Procedure

- Measure and record the length I of the inclined plane.
- Measure the height h of the upper end of the inclined plane from the drawn horizontal line (Fig. 1) and record its value in Table 1.
- Hang the roller on the traction cord of the left dynamometer. Measure the weight F_G of the roller and record it.
- Place the roller onto the inclined plane, and move the dynamometer until its traction cord is parallel to the inclined plane.
- Also connect the right dynamometer with the roller. Shift it until the traction cord is perpendicular to the inclined plan and the roller is lifted slightly from the plane.

  Note: The angle between $\overrightarrow{F_H}$ and $\overrightarrow{F_N}$ is exactly a right angle when F_N is minimal. This can be achieved by making small changes in the position of the dynamometer for F_N until a right angle has been formed.
- Record the values for F_H and F_N in Table 1.
- Increase angle α in 15° steps. Record the respective values for F_H, F_N and h in Table 1.
- For a constant angle, e.g. α= 60°, determine the values for F_H and F_N with reduced weight $\overrightarrow{F_G}$ of the roller. To achieve this, first unscrew and remove one of its supplementary weights (each 50 g); subsequently, the other one. In each case measure F_G as described at the beginning of this experiment and then determine F_H and F_N. Record the measured values.

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Observation and evaluation

Observation

Table 1, l = 31 cm

F_G/N	$\alpha/1^\circ$	F_H/N	F_N/N	h/cm	F_H/F_G
2.0	15	0.53	1.94	8.1	0.26
2.0	30	1.00	1.74	15.5	0.50
2.0	45	1.40	1.40	22.0	0.70
2.0	60	1.75	1.00	26.0	0.87
1.51	60	1.30	0.75	26.8	0.86
0.99	60	0.86	0.50	26.8	0.86

Evaluation

For a constant weight $\overrightarrow{F_G}$ the larger the angle of slope - and thus the height of the inclined plane - the larger the downs lope force $\overrightarrow{F_H}$ and the smaller the perpendicular (normal) force $\overrightarrow{F_N}$.
To be able to make quantitative statements, calculatethe quotient $F_\mathrm{H}/F_\mathrm{G}$, and the following is obtained (within the given limits of the measuring accuracy):

F_H/F_G = konstant.

As can be seen subsequent to quotient formation (et. Table 1), this constant has a value of h/I, therefore:

$\frac{F_H}{F_g} = \frac{h}{l}$ oder $F_H = \frac{F_G * h}{l}$

Using this equation, F_H can be calculated.

The drawing on the demonstration board (cf. Fig. 2) corroborates the corresponding facts.

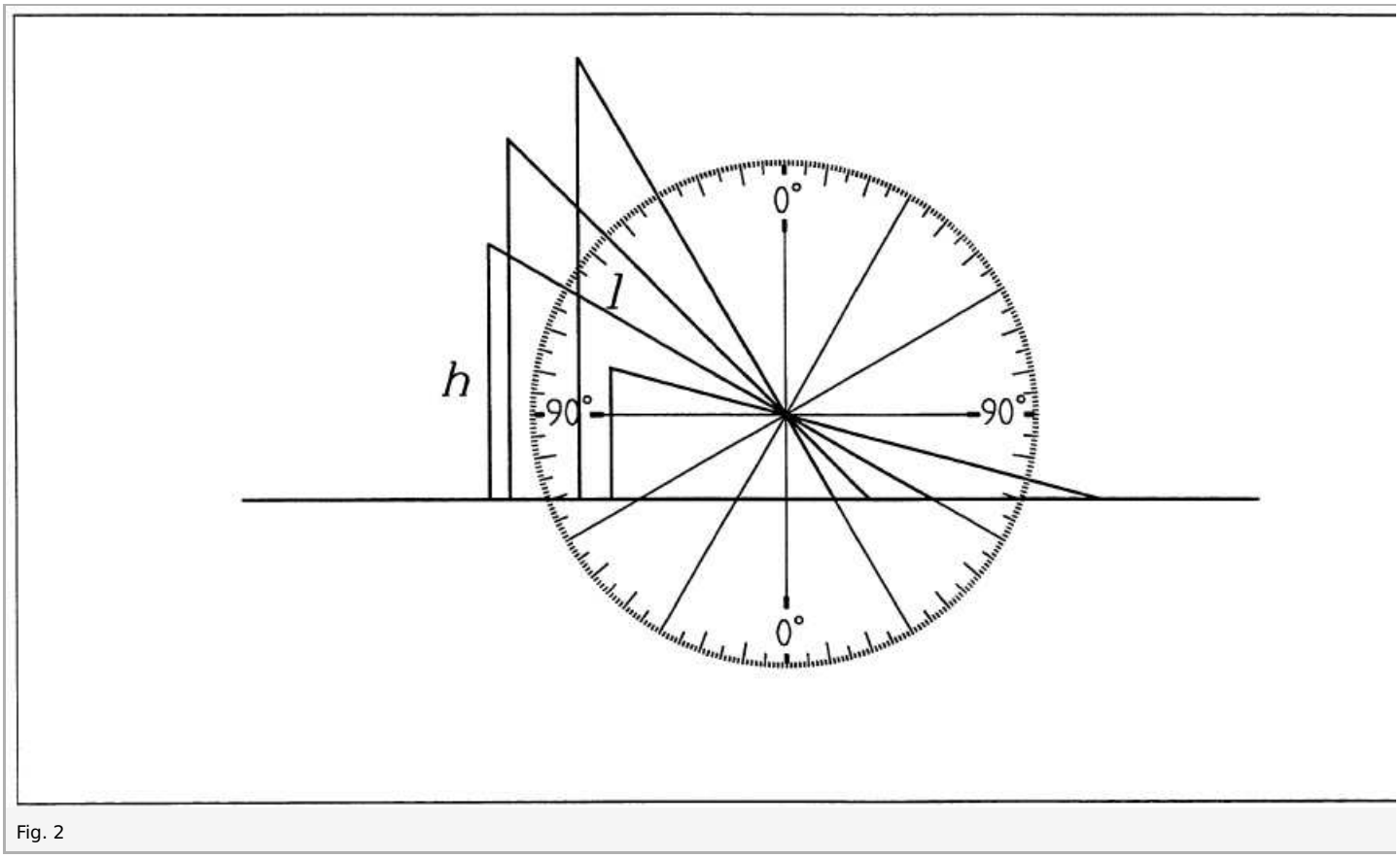

Fig. 2

$\overrightarrow{F_H}/\overrightarrow{F_G} = constant$ also means $F_H \sim F_G$. This can be confirmed with the results of the last two measuring steps

(cf. the last two lines in Table 1).

Remarks

If the students have appropriate previous knowledge of trigonometry, the result can also be written in the following form:

$\frac{F_H}{F_G} = \sin(\alpha)$ or $F_H = F_G + \sin(\alpha)$

It is advisable to use the student's existing knowledge of force resolution and the similarity of triangles to allow the students to predict the result of the measurements with the aid of a corresponding sketch (Fig. 3). In this case, the experiment has now become a confirmation experiment with the advantage that the individual steps leading to the results can be taken with more clarity over the objective. A planning drawing for the measurements, similar to that shown in Fig. 2, can be drawn on the demonstration board even before the experiment. The correlation between the downslope force and the angle of slope can also be elaborated by using weights to preset specific values for F_H and the corresponding angle, determined. To achieve this, a roller (02262.00) is attached to the inclined plane with the help of the thumb screw.

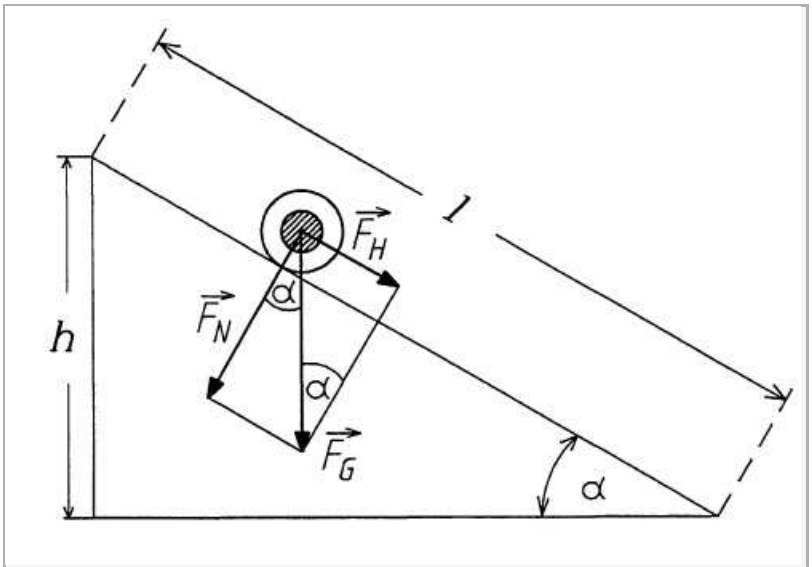

Fig. 3

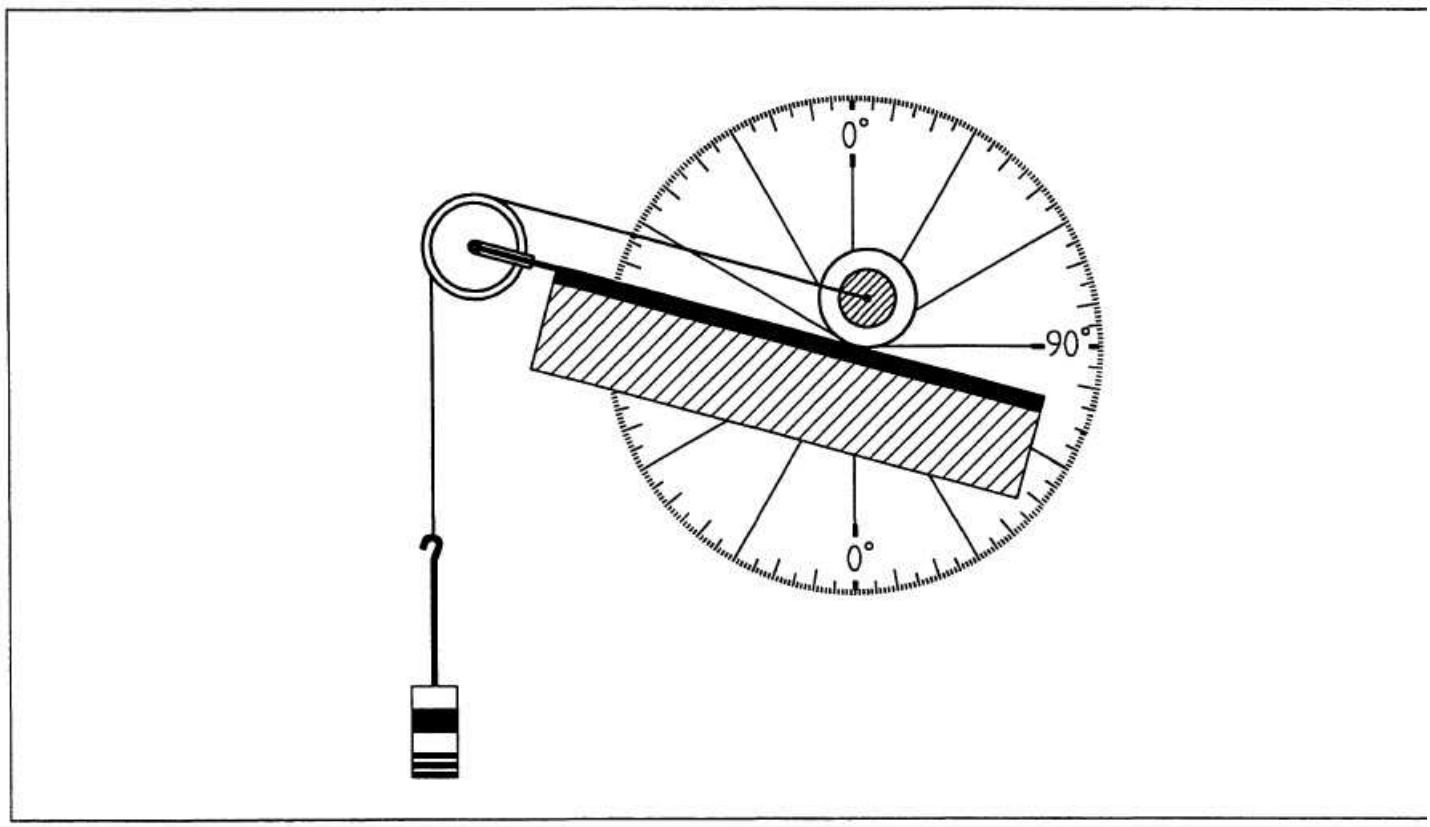

Fig. 4