Inclined plane: force along the plane and force normal to the plane

Objects of the experiment

- Measuring the force F_1 along the plane and the force F_2 normal to the plane of a body on an inclined plane as a function of the angle of inclination α.
- Comparing the measured forces F_1 and F_2 with the forces calculated through vectorial resolution of the force of gravity G.

Principles

The motion of a body on an inclined plane can be described most easily when the force exerted by the weight ***G*** (force of gravity) on the body is vectorially resolved into a force $\boldsymbol{F}_1$ along the plane and a force $\boldsymbol{F}_2$ normal to the plane. The force along the plane acts parallel to a plane inclined at an angle α, and the force normal to the plane acts perpendicular to the plane (see Fig. 1). For the absolute values of the forces, we can say

$$F_1 = G \cdot \sin \alpha \qquad \text{(I)}$$

and

$$F_2 = G \cdot \cos \alpha \qquad \text{(II)}$$

The experiment verifies this resolution. Here, the two forces F_1 and F_2 are measured for various angles of inclination α using precision dynamometers. We can vary the angle of inclination α by moving a support with the height h = 5 cm to various distances s between the pivot of the inclined plane and the support point (see Fig. 1). We can say

$$\sin \alpha = \frac{h}{s} \qquad \text{(III)}$$

and

$$\cos \alpha = \sqrt{1 - \left(\frac{h}{s}\right)^2} \qquad \text{(IV)}$$

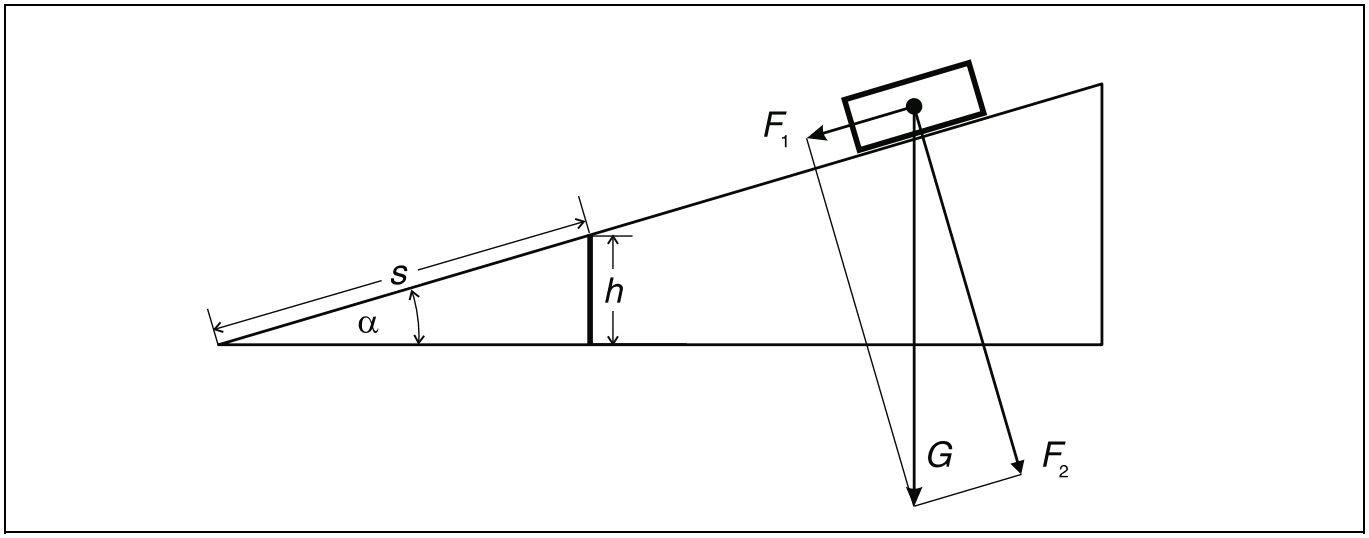
(I) and (III) give us the force along the plane

$$F_1 = G \cdot \frac{h}{s} \qquad \text{(V)}$$

and (II) and (IV) give us the force normal to the plane

$$F_2 = G \cdot \sqrt{1 - \left(\frac{h}{s}\right)^2} \qquad \text{(VI)}$$

Fig. 1 Vectorial resolution of the force of gravity G into the force F_1 along the plane and the force F_2 normal to the plane on an inclined plane



Apparatus

1 Inclined plane with trolley and screw model 341 21

1 Precision dynamometer, 1.0 N 314 141

Setup and carrying out the experiment

a) Correcting the zero point of the dynamometer

– Lay out dynamometer F_1 horizontally and correct the zero point.
– Hold dynamometer F_2 vertically downward and correct the zero point.

b) Determining the force of gravity

– Suspend the trolley freely from dynamometer F_2 using the folding metal hook and determine the weight G of the trolley.

c) Determining the force along the plane and the force normal to the plane

– Set up the inclined plane and position the support **(e)** at s = 50 cm.
– Place the trolley **(b)** on the inclined plane and hook it to dynamometer F_1 **(c)**; support the dynamometer with block **(d)**.
– Carefully arrange dynamometer F_2 **(a)** as nearly perpendicular as possible to the inclined plane and lift the trolley until it is just barely touching the plane surface.
– Read off and write down forces F_1 and F_2.
– Move the ramp support **(b**) to the positions s = 40, 30, 20, 15 and 10 cm one after another; each time arrange the dynamometer perpendicular to the inclined plane and read off and write down forces F_1 and F_2.

Measuring example

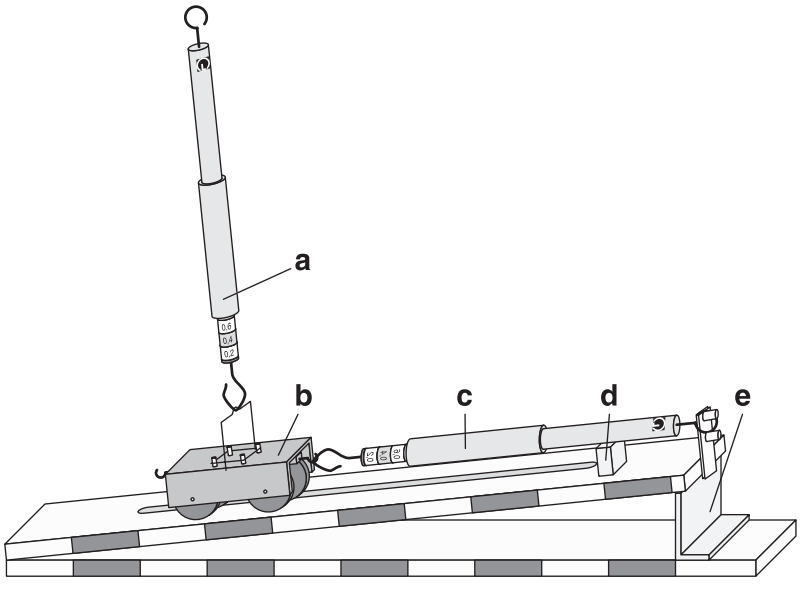
h = 5 cm

G = 1.07 N

Table 1: Position s of ramp support and forces F_1 and F_2 on the inclined plane

$\frac{s}{\text{cm}}$	$\frac{F_1}{\text{N}}$	$\frac{F_2}{\text{N}}$
50	0.10	1.01
40	0.12	0.98
30	0.18	0.97
20	0.27	0.97
15	0.35	0.95
10	0.59	0.81

Fig. 2 Experiment setup for determining the force along the plane and force to the plane



Evaluation and results

Tables 2 and 3 enable a comparison of the measured forces and those calculated using (V) and (VI). Fig. 3 shows the results plotted in a graph.

For the force normal to the plane we see a systematic deviation between the measured and calculated values. This is due to the fact that the trolley is still partially supported when the force is measured.

Table. 2: Measured an calculated force F_1 along the plane

$\frac{s}{\text{cm}}$	$\frac{F_1}{\text{N}}$ measured	$\frac{F_2}{\text{N}}$ calculated
50	0.09	0.107
40	0.12	0.134
30	0.18	0.178
20	0.27	0.268
15	0.33	0.357
10	0.53	0.535

Table 3: Measured an calculated force F_2 normal to the plane

$\frac{s}{\text{cm}}$	$\frac{F_1}{\text{N}}$ measured	$\frac{F_2}{\text{N}}$ calculated
50	1.01	1.065
40	0.98	1.062
30	0.97	1.055
20	0.97	1.036
15	0.95	1.009
10	0.81	0.927

Fig. 3 Measured (solid line) and calculated (points) values for the force F_1 along the plane and the force F_2 normal to the plane