Determining the coefficient of static friction using the inclined plane

**Objects of the experiment**

- Determining the coefficient of static friction $\mu$ from the equilibrium between the force along the plane and the static friction force on an inclined plane

**Principles**

A body on an inclined plane with the weight $G$ is subject to a force along the plane (parallel to the plane) of

$$F_1 = G \cdot \sin \alpha$$  \hspace{1cm} (I)

and to a force normal (perpendicular) to the plane of

$$F_2 = G \cdot \cos \alpha$$  \hspace{1cm} (II)

This dependency on the angle of inclination $\alpha$ can be used to determine quantitatively the coefficient of friction $\mu$ of the body. The angle of inclination of the plane is increased by moving the support until the body just begins to slide, i.e. the force $F_1$ along the plane and the static friction force $F$ are in equilibrium. In this experiment the tangent of the angle of inclination is determined from the height $h = 5 \text{ cm}$ of the support and its distance $s$ from the pivot of the inclined plane are measured.

$$\tan \alpha = \frac{h}{s}$$  \hspace{1cm} (III)

The static friction force is generally taken to be proportional to the force $F_2$ along the plane:

$$F = \mu \cdot F_2$$  \hspace{1cm} (IV)

From the equilibrium of forces $F_1 = F$ we can deduce:

$$F_1 = \mu \cdot F_2$$  \hspace{1cm} (V)

$\mu$: coefficient of friction
and thus from (I), (II) and (III)

$$\mu = \frac{h}{s}$$  \hspace{1cm} (VI).

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Fig. 1  Equilibrium between the force $F_1$ along the plane and the static friction force $F$ on an inclined plane.
Setup and carrying out the experiment

- Set up the inclined plane and move the support (a) to the farthest possible point from the pivot.
- Place block 1 (6 cm thick) on the inclined plane with the plastic-coated side down and slowly move the support inward until the block starts to slide.
- Measure the distance between the pivot and the support using the tape measure and calculate the coefficient of static friction using equation (VI).
- Place block 1 on the plane with the wooden side down and repeat the experiment.
- Place block 2 (3 cm thick) on the inclined plane with the plastic-coated side down and repeat the experiment.
- Turn the wooden surface with the area $A = 12 \times 6 \text{ cm}^2$ down and repeat the experiment.
- Turn the wooden surface with the area $A = 12 \times 3 \text{ cm}^2$ down and repeat the experiment.

Measuring example and evaluation

<table>
<thead>
<tr>
<th>Block</th>
<th>Material</th>
<th>$A_{\text{cm}^2}$</th>
<th>$s_{\text{cm}}$</th>
<th>$\mu$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Plastic</td>
<td>$12 \times 6$</td>
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<td>0.48</td>
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<tr>
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<td>Wood</td>
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<td>21.9</td>
<td>0.23</td>
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<td>9.5</td>
<td>0.53</td>
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<td>$12 \times 6$</td>
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<td>0.24</td>
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<tr>
<td>2</td>
<td>Wood</td>
<td>$12 \times 3$</td>
<td>21.1</td>
<td>0.24</td>
</tr>
</tbody>
</table>

Results

The coefficient of static friction depends on the material of the contact surface, but not on its surface area.

Fig. 2  Experiment setup for determining the coefficient of friction on an inclined plane