Frictional force (Item No.: P1252900)

Curricular Relevance

Area of Expertise:	Education Level:	Topic:	Subtopic:	Experiment:
Physik	Klasse 7-10	Mechanik	Kräfte, einfache Maschinen	Reibungskraft

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 sliding friction is:

- smaller than static friction,
- proportional to the normal force,
- a function of the nature of the contact surfaces

and

- independent of the size of the contact surface.

Equipment

Position No.	Material	Order No.	Quantity
1	Demo Physics board with stand	02150-00	1
2	Torsion dynamometer	03069-03	1
3	Inclined plane for demonstration board	02152-00	1
4	Friction block	02240-01	1
5	Holding pin	03949-00	1
6	Slotted weight, black, 50 g	02206-01	2
7	Slotted weight, silver bronze, 50 g	02206-02	2

Set-up and procedure

Set-up

- Place the adjustable surface (plane) onto the demonstration board and ensure that it is horizontal.
- Position the dynamometer at approximately the same height and set it to zero.
- Measure the weight F_G of the friction block and record it.
- Place the friction block with its rubberised surface downwards onto the plane.
- Hook the traction cord of the dynamometer onto the friction block's hook and shift the position of the dynamometer until the traction cord is parallel to the plane (Fig. 1).

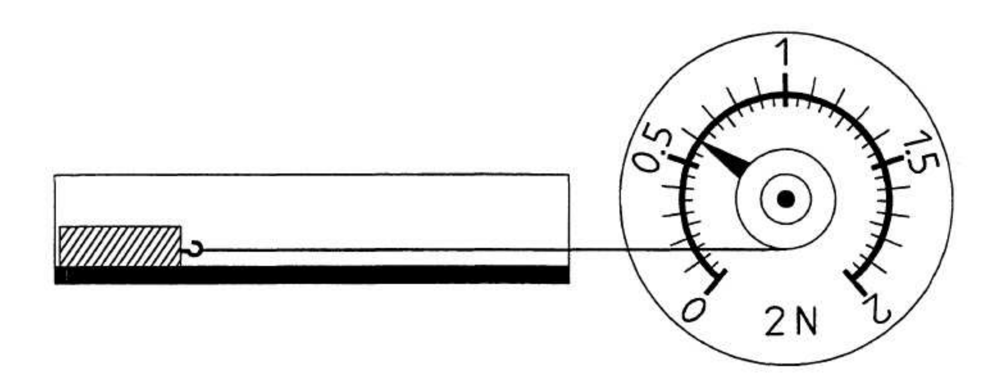

Fig. 1

Procedure

- Move the dynamometer slowly, but as uniformly as possible to the right; observe the deflection of the needle and the movement of the block.
- If necessary, repeat the procedure several times; record your observation.
- Using the holding pin, load the friction block successively with 1 , 2 and 3 50-g slotted weights thus increasing F_G. Measure the sliding friction F_r for the respective weights (if necessary, use the 4-N measuring range) and record the values in Table 1.
- Remove the slotted weights and the holding pin.
- First, lay the friction block with its largest non-rubberised surface on the plane, then with the intermediate non-rubberised one downwards. Measure
F_r in both cases as above. Record the values.

Observations and evaluation

Observations

$$F_G = 0.86N$$

At the beginning of the movement of the friction block the frictional force is larger than during its uniform movement. Sample measurement: The dynamometer needle is initially deflected by approximately 0.7 N and subsequently remains steady at approximately on 0.6 N.

Table 1 (sample measurement)

Contact surface	F_G/N	F_R/N	F_R/F_G
large, rubber	0.86	0.60	0.70
	1.42	0.91	0.64
	1.92	1.36	0.71
	2.42	1.75	0.72
	2.92	2.15	0.74
large, wooden	0.86	0.12	0.14
intermediate, wooden	0.86	0.12	0.14

Evaluation

In order to move bodies, one of which lies upon the other, uniformly a force is required which overcomes the frictional force F_r. The force wh ich opposes the
movement results from the fact that the surfaces of the bodies which are in contact with each other "interlock". Interlocking can not take place to the same extent during movement as at rest. Therefore, the frictional force is larger at the instant of the onset of movement as during movement.

This corresponds to the observation, and formulated as a concept, it is stated as follows: The sliding frictional force $\overrightarrow{F_r}$; is smaller than the static frictional force $\overrightarrow{F_h}$;

$$F_r < F_h \ .$$

As Table 1 (upper part) shows, the frictional force increases with the weight F_G. If one forms the quotient F_r / F_G, one obtains, within the limits of the measurement accuracy, a constant, which is termed the coefficient of friction μ and which has a mean value of 0.7 under the given experimental conditions.

Therefore:

$$F_r = \mu * F_G \ .$$

In this experiment $\overrightarrow{F_G}$ acts perpendicularly to the sliding surface. If the sliding surface is not horizontal, then only a component of $\overrightarrow{F_G}$, the normal force $\overrightarrow{F_N}$' is decisive for the sliding friction. Consequently, the following is valid in the general case:

$$F_r = \mu * F_N \ .$$

A comparison of the measured values in Table 1, first and last lines, shows that the frictional force F_r is dependent on the nature of the contact surfaces.

A comparison of the measured values in the last two lines of Table 1 shows that the frictional force is independent of the magnitude of the contact surfaces.

Remarks

This experiment can be expanded by scattering sand onto the surface of the inclined plane. Or one can cut a strip of sand paper or other material, place
it onto the plane and secure it against slipping with the thumbscrew. In this manner, additional coefficients of friction can be determined.

These experimental results are only a good approximation. In reality there are many factors which require special consideration. Thus, on auto tyres having
a sophisticated tread, the width of the contact surfaces may have a great influence on the sliding friction and thus on the roadability (e.g. the tyres of race cars).

The frictional force F_r can also be determined by progressively increasing the force acting horizontally on the block by adding weights and by pushing the block until a movement of the block with constant velocity results. To achieve this, a roller (03970-00) is attached to the inclined plane using the thumb screw (Fig. 2); in addition, 1-g weights (03916-00) will generally be required.

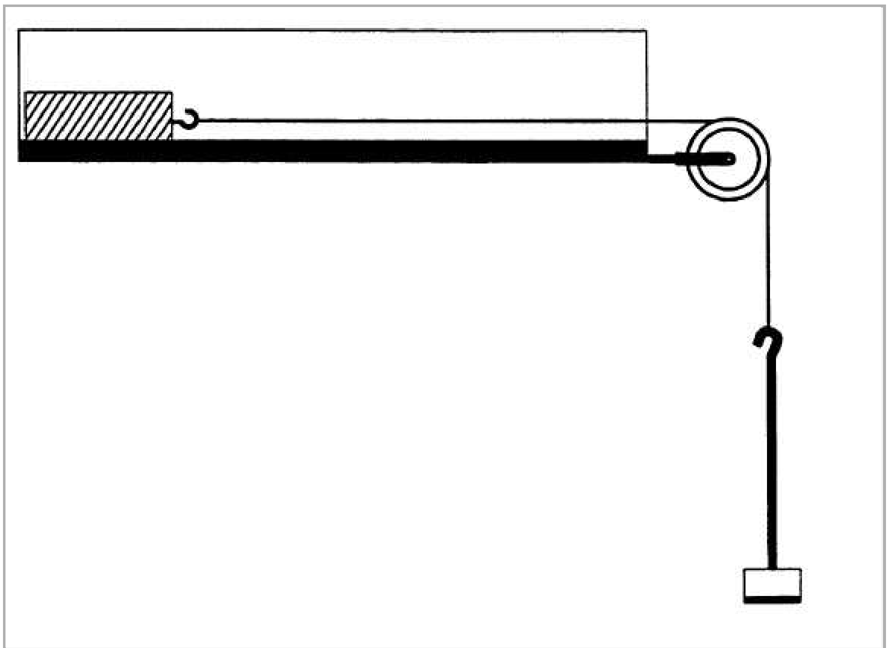

Fig. 2