Mechanics

Forces

PHYSICS EXPERIMENT

Inclined Planes

DETERMINE THE FORCES ACTING ON AN INCLINED PLANE.

- Measure the component F_1 of the weight of an object which acts down an inclined plane as a function of the angle of inclination α.
- Plot the ratio of the component F_1 to the weight G as a function of sin α.

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GENERAL PRINCIPLES

If a body needs to be propelled up an inclined plane, it is not the body's full weight *G* which needs to be overcome, but only the component which acts parallel to the plane F_1. The vector differential between the weight and the component down the plane is represented by the component normal to the plane F_2, see Fig. 1.

The magnitudes of the forces are given by the following relationships:

$$F_1 = G \cdot \sin\alpha \quad (1)$$

$$F_2 = G \cdot \cos\alpha\,. \quad (2)$$

In this experiment, the body is suspended from a cord which runs over a pulley. The force along the plane is then compensated for by weights on a weight holder suspended from the other end of the cord. Since the friction between the body and the inclined plane is of importance, the value used for the measurements is an average of the lowest and highest values, where the component of the force down the plane is just enough to stop the body sliding down the slope and when it is just enough not to drag it up the slope. The weight of the body *G* is determined in advance using a dynamometer. The weight of the weight holder is also taken into account. The angle of inclination *α* can simply be read from a protractor scale.

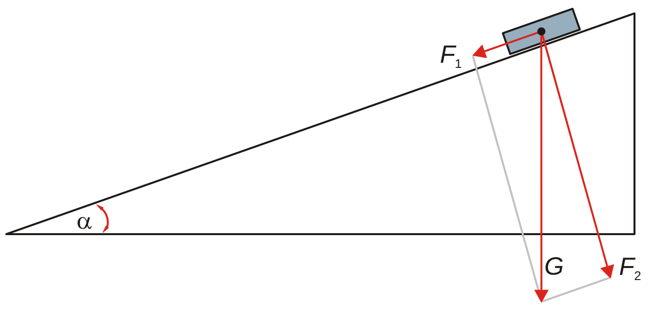

Fig. 1: Resolution of the weight ***G*** into vector components parallel to the plane, F_1, and normal to the plane, F_2

LIST OF EQUIPMENT

1	Inclined Plane	1003213 (U30015)
1	Precision Dynamometer 5 N	1003106 (U20034)
1	Set of Weights 1 g to 500 g	1010189 (U29576)

EXPERIMENT PROCEDURE

Fig. 2: Experiment set-up

- Hold the dynamometer vertical and calibrate the zero point.
- First determine the weight in newtons *G* of the roller and then that of the pan G_T. Make a note of these values.
- Set the inclined plane to an angle of inclination α = 10°.
- Put the roller on the inclined plane, run the cord over the pulley and place enough weights in the pan at the other end of the cord so that the roller cannot roll either up or down the plane.
- By removing or adding weights to the pan, find out the minimum and maximum mass of the weights at which the roller *is just prevented* from rolling up or down the plane. Enter the values for the maximum and minimum masses into Table 1.

- Keep steepening the angle of the plane in steps of 5° (the maximum angle which can be set is 44°), find out the maximum and minimum masses which keep the roller still for each angle and enter the values into Table 1.
- For each pair of values you measure for the maximum and minimum masses, find the average $\bar{m}$ and enter it into Table 1.

SAMPLE MEASUREMENT AND EVALUATION

Weight of roller G in newtons 2.25 N

Weight of pan G_T in newtons 0.38 N

Table 1: Maximum, minimum and averaged masses for various angles.

α	m_{min} / g	m_{max} / g	$\bar{m}$ / g
10°	2	5	3.5
15°	15	20	17.5
20°	30	45	37.5
25°	50	60	55.0
30°	70	80	75.0
35°	90	100	95.0
40°	120	100	110.0
44°	105	130	117.5

- Calculate the force along the plane F_1 with the help of equation (1) for each angle and enter the values into Table 2.
- Determine the force along the plane F_1^m from the measurements according to the following formula:

  (3) $F_1^m = G_T + \bar{m} \cdot g$

  Enter the values obtained into Table 2.
- Compare the values of the force along the plane by calculation F_1 and by measurement F_1^m.
- In each case, calculate the quotient of the average measured force along the plane F_1^m and the weight G of the roller. Enter these values into Table 2.
- Plot the quotient F_1^m/G as a function of sin α, fit a straight line through the origin to the points and verify the truth of equation (1) using the following relationship:

  (4) $F_1^m / G = 1 \cdot \sin\alpha$

Table 2: Force along inclined plane by calculation and by measurement plus ratio of measured force to weight of roller for various angles of inclination.

α	sin α	F_1 / N	F_1^m / N	F_1^m / G
10°	0.174	0.39	0.41	0.182
15°	0.259	0.58	0.55	0.244
20°	0.342	0.77	0.75	0.333
25°	0.423	0.95	0.92	0.409
30°	0.500	1.12	1.12	0.498
35°	0.574	1.29	1.31	0.582
40°	0.643	1.44	1.46	0.649
44°	0.695	1.56	1.53	0.680

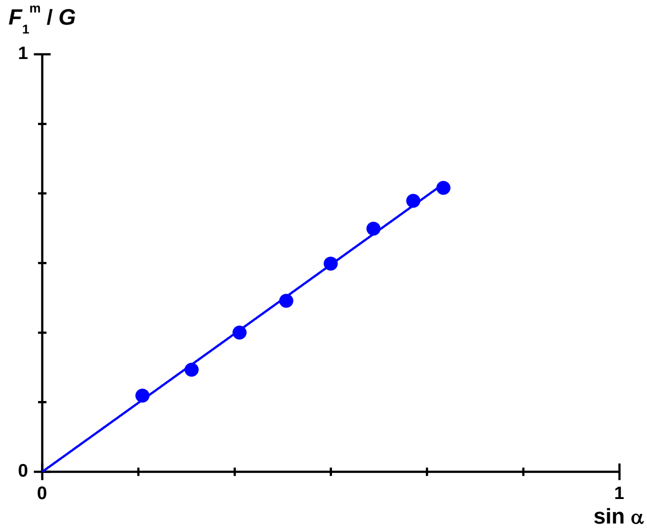

Fig. 3: The ratio between the parallel component F_1^m and the weight $\mathbf{G}$ as a function of sin α.

The calculated values F_1 are well in agreement with those found by measurement F_1^m (Table 2).

Within the tolerances of the measurement, the quotients F_1^m/G plotted against sin α lie, as expected along a straight line through the origin with a gradient of 1 (Fig. 3).