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Physics Laboratory Report

Title 表題

Friction

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Summary

We measured the maximum static frictional force and kinetic frictional force by drawing a wooden block. We also measured the maximum static frictional force by another method, letting the object slide on the board. During those experiments, we changed the mass of the object, the area of contact surface, and the type of the board. Finally, we examined whether these factors affect the frictional force or not, and found that only mass of the object and type of the board decide the frictional force, following the formula $F_0 = \mu N$, $F' = \mu' N$.

Addition/Correction 追加／修正		

・Meet a deadline ・Write logically ・Write clearly ・Write with your own words

・締切り守って ・論理的に ・わかりやすく ・自分のことばで

* Write your report in Japanese or in English * Use this form as a front cover.

* Submit your reports by the seventh day after your lab. You can add to or correct your report: note when you have done this.

I. Introduction

1. Objectives

Calculate the maximum static frictional force and kinetic frictional force. Examine the relationships between mass of the object and friction, and contact surface and friction.

2. Theory

✓ Maximum static frictional force is bigger than kinetic frictional force. As shown in Figure 1, the frictional force increases with time when the object is static, and the force suddenly drops down at the point where the object starts to move. Kinetic frictional force is constant after that point.

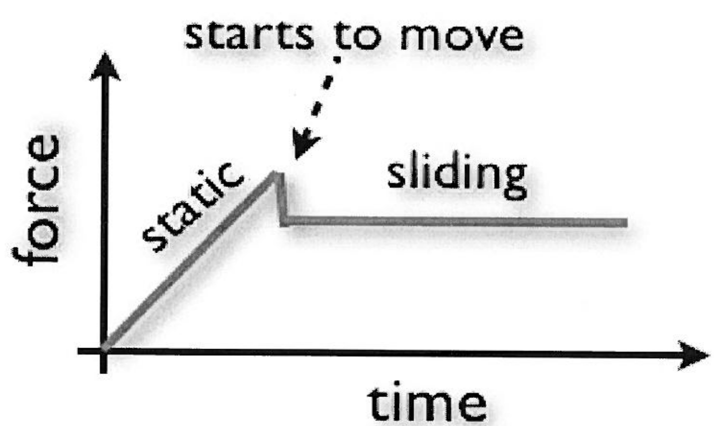


Figure 1: cited from scienceblogs.com

✓ Both maximum static frictional force and kinetic frictional force are directly proportional to the mass of the object when N and mg are equal.

$$F_0 = \mu N, \;\; F' = \mu' N$$

In other words, frictional force depends only on the coefficient of friction (μ) and vertical drag (N), so the contact surface does not affect the force.

II. Experiment

1. Apparatus

- Wooden board
- Spring balance
- Wooden block
- Pulley
- String
- Weight (250g)

2. Methods

[Part A]

① Adjust zero of the spring balance.

② Measure the mass of the wooden block.

③ Measure the three dimensions of the block.

④ Set the apparatus as shown in Figure 2.

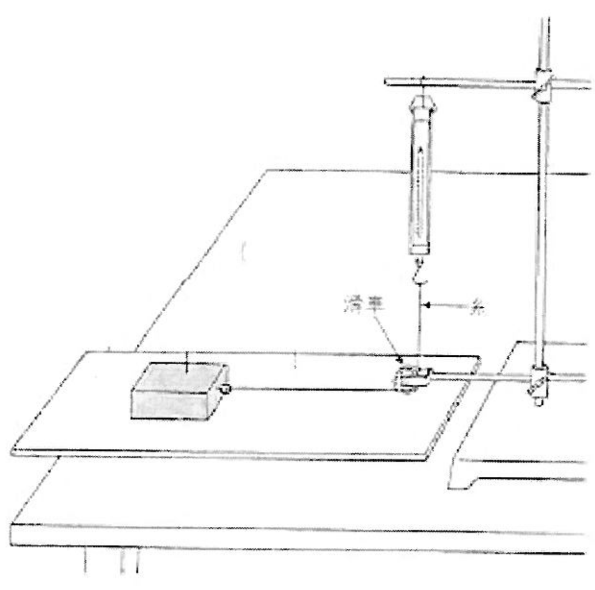


Figure 2: cited from tmoritani.com

Make sure that the board and string on the block's side are parallel. Make the string from the spring balance vertical.

⑤ Drag the board slowly, and read the scale of spring balance right before the wooden block starts to move. Then read the scale when the block is moving. Do this three times and get the average value.

⑥ Put a 250g weight onto the wooden block and do the same thing. Then change the number of weights.

⑦ Change the placement of the block (the area of contact surface) and do the same experiment.

⑧ Turn the board over and do the same experiment. The backside of the board is not smooth at all and is rough.

[Part B]

① Tilt the board and find the angle of it when the block starts to slide. By measuring the length and height of the board, you can find the angle.

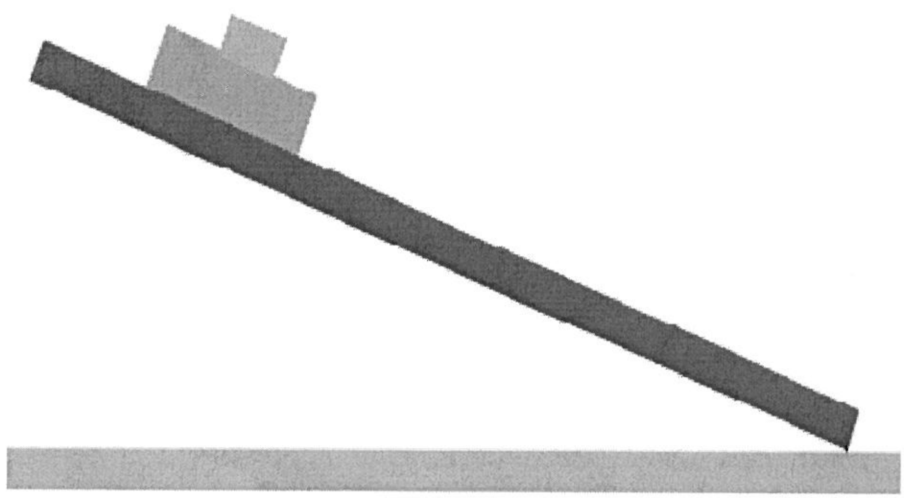


Figure 3: cited from dev.physicislab.org

② Find the coefficient of friction by using the formula: $\mu = \tan\theta$.

③ Change the mass of the block by putting weights on it and do the same experiment.

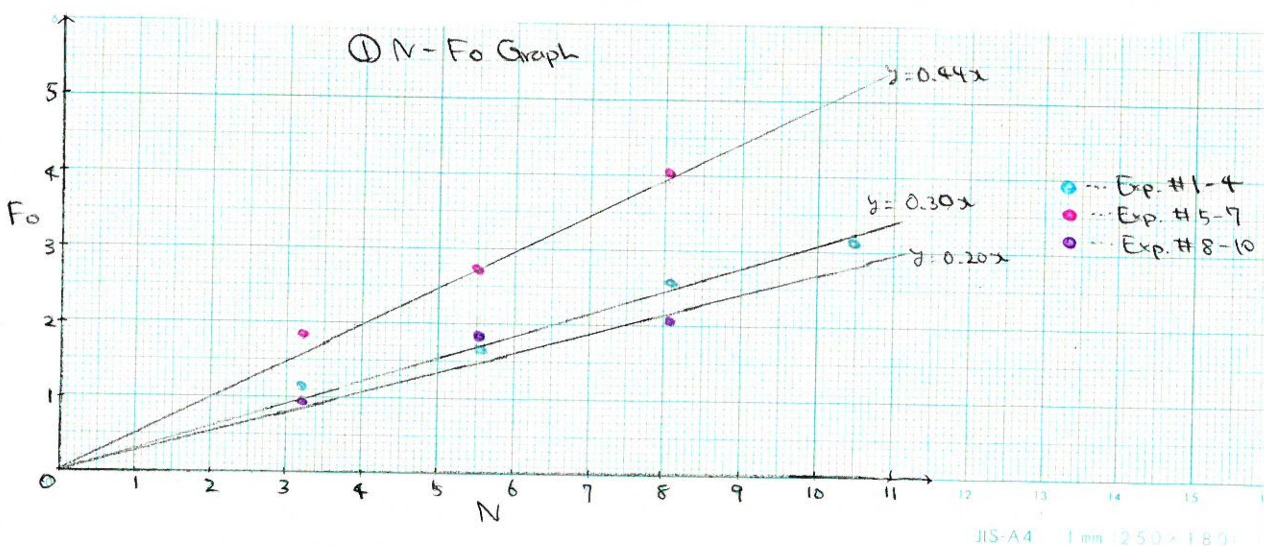
④ Change the contact surface of the block and do the same experiment.

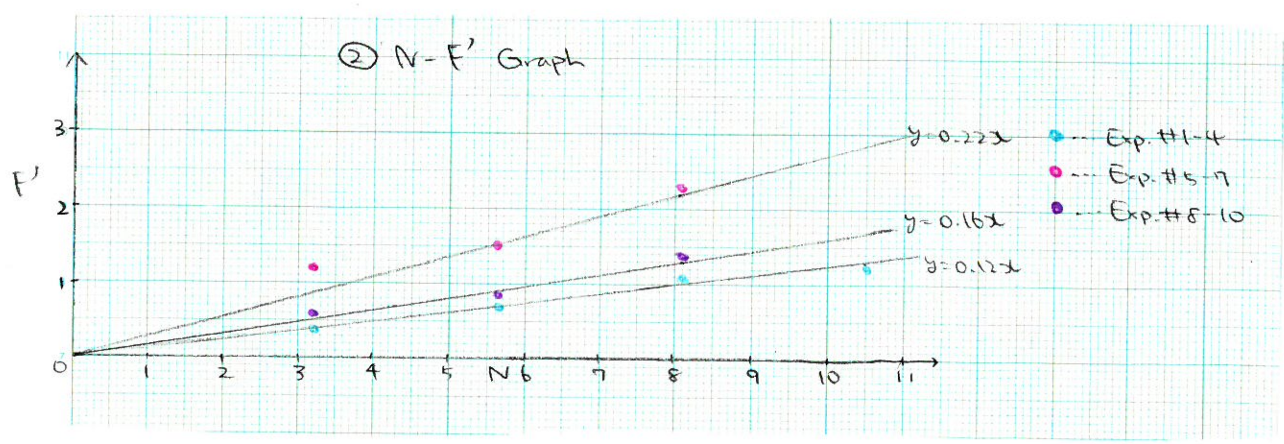
⑤ Compare these results to the coefficients of friction found in Part A.

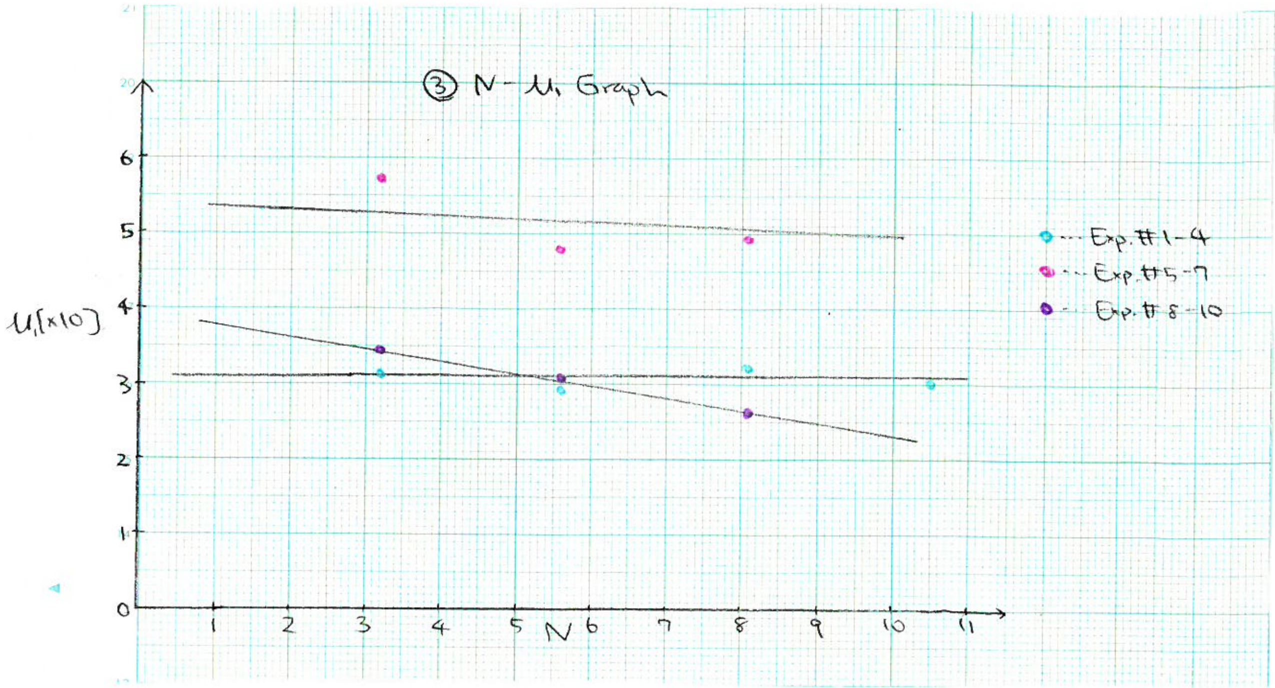
III. Results

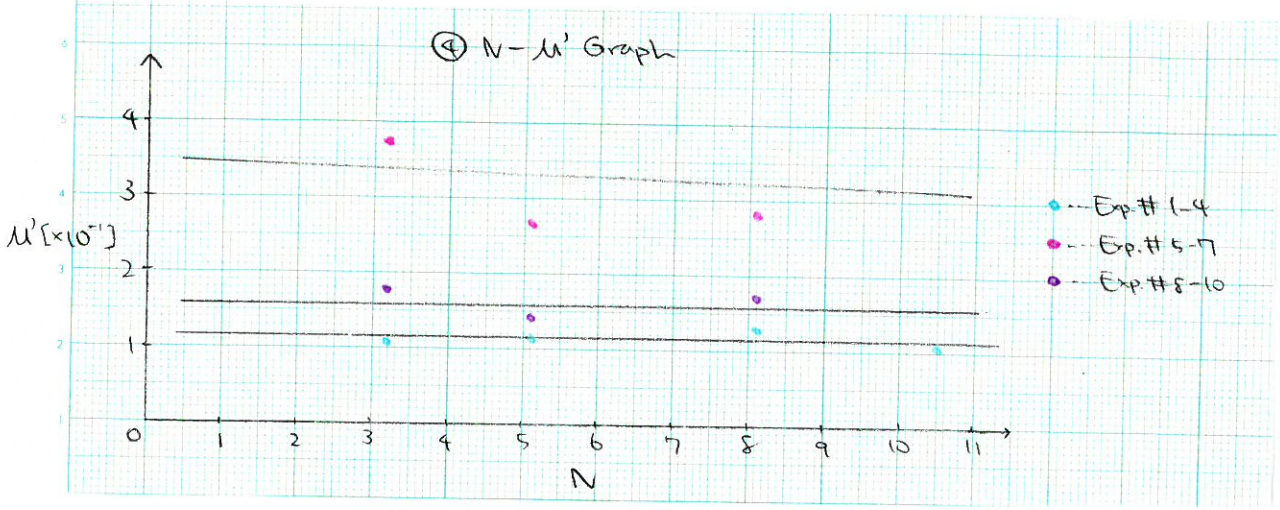
Exp. #	1	2	3	4	5	6	7	8	9	10
Surface of the board	Smooth	Smooth	Smooth	Smooth	Rough	Rough	Rough	Smooth	Smooth	Smooth
Area of contact surface [m^2]	1.74 $\times 10^{-2}$	1.74 $\times 10^{-2}$	1.74 $\times 10^{-2}$	1.74 $\times 10^{-2}$	1.74 $\times 10^{-2}$	1.74 $\times 10^{-2}$	1.74 $\times 10^{-2}$	4.38 $\times 10^{-3}$	4.38 $\times 10^{-3}$	4.38 $\times 10^{-3}$
Mass of block + weights [$\times 10^{-3} kg$]	326	576	826	1076	326	576	826	326	576	826
Normal force (N) [N]	3.19	5.64	8.09	10.5	3.19	5.64	8.09	3.19	5.64	8.09
Maximum static frictional force (F_0) [N]	1.00	1.67	2.60	3.16	1.83	2.70	4.00	1.10	1.70	2.10
Kinetic frictional force (F') [N]	0.37	0.66	1.08	1.20	1.20	1.50	2.26	0.57	0.83	1.37
Coefficient of static friction (μ_1) $\mu = \frac{F_0}{N}$	0.313	0.296	0.321	0.301	0.574	0.479	0.494	0.345	0.301	0.260

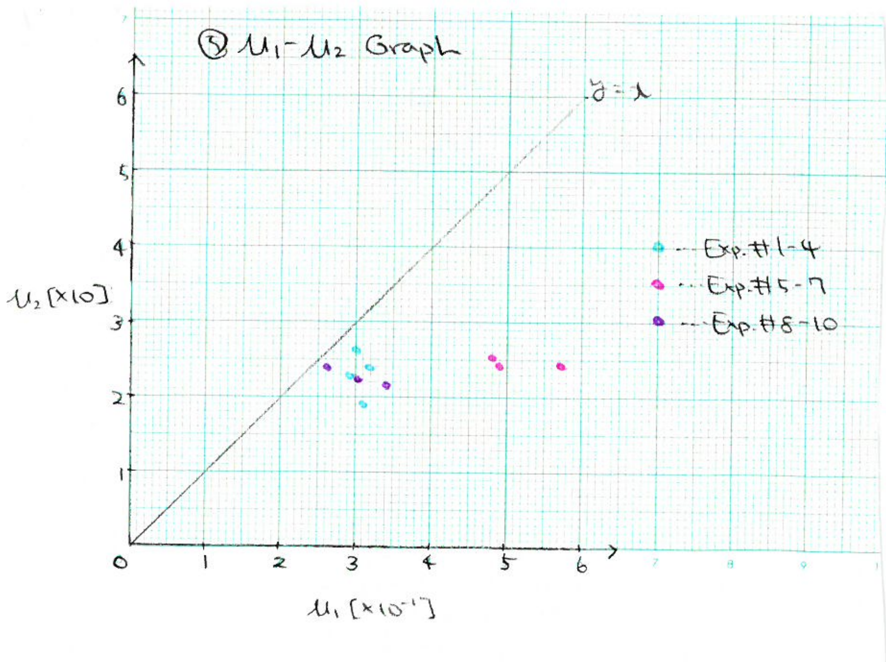
Coefficient of kinetic friction (μ') $\mu' = \frac{F'}{N}$	0.116	0.117	0.133	0.114	0.376	0.266	0.279	0.179	0.147	0.169
H/L	0.190	0.221	0.230	0.256	0.235	0.243	0.240	0.211	0.224	0.233
θ	11.0°	12.8°	13.3°	14.8°	13.6°	14.1°	13.9°	12.2°	12.9°	13.5°
Coefficient of static friction (μ_2) $\mu = \tan\theta$	0.194	0.227	0.236	0.264	0.242	0.251	0.247	0.216	0.229	0.240

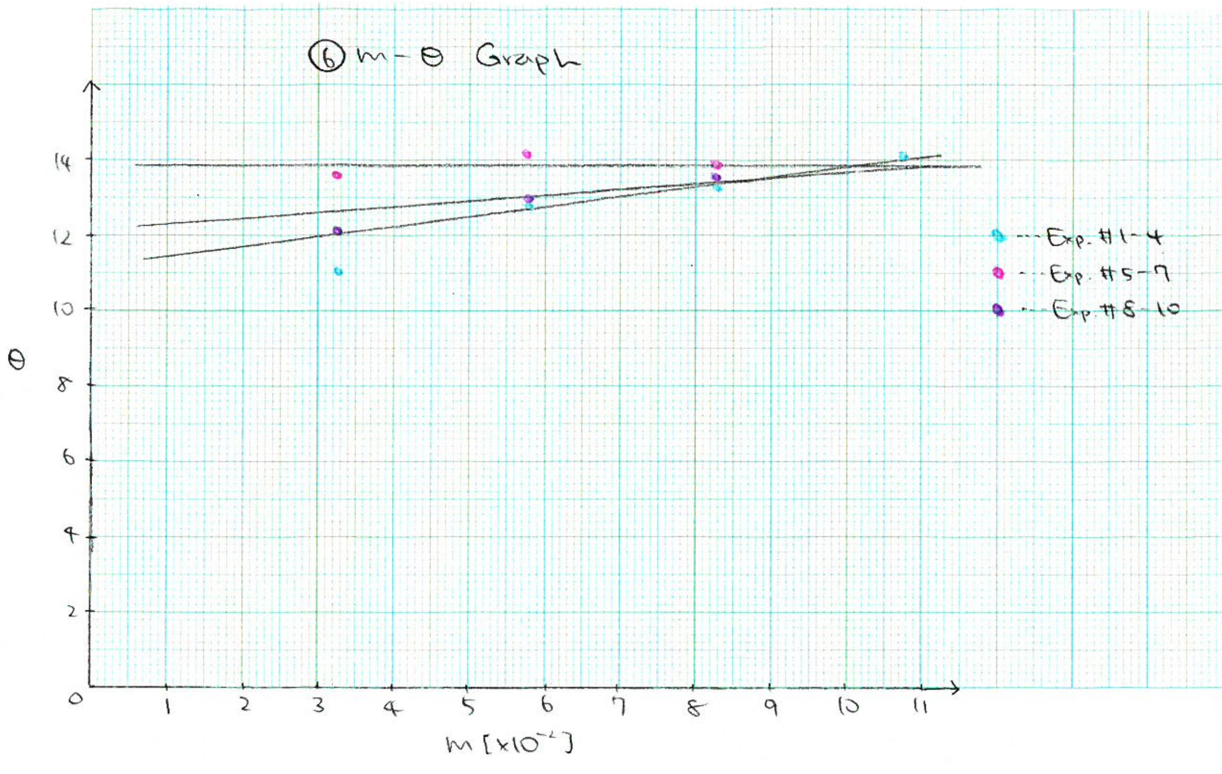




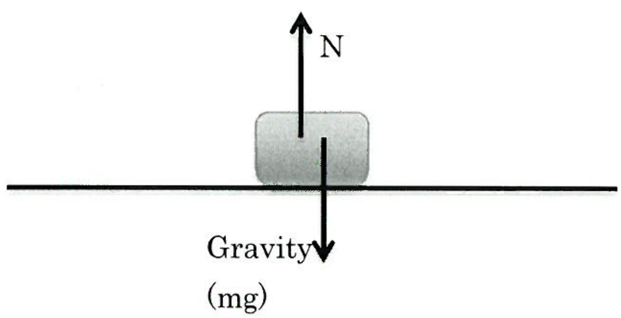

③ N-μ₁ Graph
μ₁[×10]
N
0
1
2
3
4
5
6
7
8
9
10
11
Exp.#1-4
Exp.#5-7
Exp.#8-10


④ N-μ' Graph
μ'[×10⁻¹]
N
0
1
2
3
4
5
6
7
8
9
10
11
Exp.#1-4
Exp.#5-7
Exp.#8-10


⑤ μ₁-μ₂ Graph
y=x
μ₂[×10]
μ₁[×10⁻¹]
0
1
2
3
4
5
6
Exp.#1-4
Exp.#5-7
Exp.#8-10



- The normal force (N) and the gravity of the object are balanced.



Therefore, N=mg.

- The maximum static frictional force (F_0) and the drawing force (f) are balanced because the object is static.

Therefore, the maximum static frictional force (F_0) is equal to the value shoed in the spring measure.

- The kinetic frictional force (F') and the drawing force (f) are balanced because of the Law of Inertia.

Therefore, the kinetic frictional force (F') is equal to the value shoed in the spring measure.

IV. Discussion

① N-F_0 Graph

From this graph, we can conclude that normal force (N) and the maximum static frictional force (F_0) are directly proportional. This proves the theory of $F_0 = \mu N$.

In addition, the lines of Exp.#1-4 and Exp.#8-10 are almost overlapped. Therefore, we can say that the contact surface is not related to the maximum static frictional force (F_0).

② N-F' Graph

From this graph, we can conclude that normal force (N) and the kinetic frictional force (F') are directly proportional. This proves the theory of $F' = \mu' N$.

In addition, the lines of Exp.#1-4 and Exp.#8-10 are almost overlapped. Therefore, we can say that the contact surface is not related to the kinetic frictional force (F').

③ $N-\mu_1$ Graph

In this graph, the lines are almost parallel to the x-axis.
From this result, we can conclude that the coefficient of static friction (μ_1) does not depend on the normal force (N).

In addition, the lines of Exp.#1-4 and Exp.#8-10 are almost overlapped. Therefore, we can say that the contact surface is not related to the coefficient of static friction (μ_1).

④ $N-\mu'$ Graph

In this graph, the lines are almost parallel to the x-axis.
From this result, we can conclude that the coefficient of kinetic friction (μ') does not depend on the normal force (N).

In addition, the lines of Exp.#1-4 and Exp.#8-10 are almost overlapped. Therefore, we can say that the contact surface is not related to the coefficient of kinetic friction (μ').

⑤ $\mu_1-\mu_2$ Graph

In this graph, the dots of Exp.#1-4, 8-10 are gathered at the same place. The dots of Exp.#5-7 are also gathered together.
From this result, we can conclude that the coefficient of static frictional force does not depend on the mass of the object and the contact surface. It only depends on the type of the board.

⑥ $m-\theta$ Graph

In this graph, the lines are almost parallel to the x-axis.
From this result, we can conclude that θ does not depend on the mass of the object.

In addition, the lines of Exp.#1-4 and Exp.#8-10 are almost overlapped. Therefore, we can say that the contact surface is not related to the angle of θ .

- The lines of Exp.#1-4 and Exp.#8-10 in graph 1-5 should be completely overlapped, but they are not.
  In addition, the lines in graph 3 and 4 should be completely parallel to the x-axis, but they are actually not.
  These are probably because we could not read the scale of the spring measure correctly.

- The dots in the graph 5 should be on the line of x=y, but they are not. This is because we moved the board little when we measured the height of it at the moment where the object started to slip.

V. Conclusions

- ✧ Both maximum static frictional force (F_0) and kinetic frictional force (F') only depend on the normal force (N) and the coefficient of static or kinetic friction (μ).
  Furthermore, because N=mg and μ depends on the type of the board, it can be said that the mass of the object and the type of the board affect the frictional force.

- ✧ $F_0 = \mu N$ and $F' = \mu' N$ are true.

VI. Opinions

It was difficult to read the scale of the spring measure instantly, so we made some error. However, conducting this experiment, I now clearly know what affect the frictional force and what do not. When we do another experiment on the next time, we would conduct it more carefully to get the accurate data.