Date of Lab 12/3/14 Date of Submission 12/12/14

Physics Laboratory Report

Title 表題

Friction

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Summary

By slowly pulling a wooden block attached to a spring scale with varying weights, contact surface area, and surface roughnesses, we measured its static and kinetic frictional force. We also found them by tilting the panel and finding the angle. From those data we derived the frictional coefficients and confirmed the following formulae:

$F_0 = \mu N \quad \mu = \tan\theta$

$F' = \mu' N$


| 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.

# 3. Introduction

## 3.1 Objectives

- To measure the maximum static friction and kinetic friction.
- To find the relationship between the mass of an object or the surface it is on with the frictional force.

## 3.2 Theory

- $F_0=\mu N$
- $F'=\mu' N$
- $N=W=mg$
- $\mu=\tan\Theta$
- The greater the normal force is acting upon an object, which is equal to its weight, greater the frictional force becomes.
- The greater the frictional coefficient of the surface, which becomes larger as it becomes rougher, greater the frictional force becomes.

## 3.3 Safety

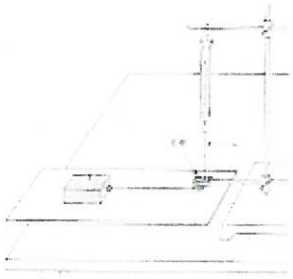
- Beware of heavy and/or large objects falling

# 4. Experimental

## 4.1 Apparatus

- Wooden panel
- Spring scale
- Wooden block
- Pulley
- String
- Weights

## 4.2 Methods



1. Set up as shown
2. Zero the spring scale
3. Make sure that the part of the string attached to the wooden block is parallel to the ground and the part attached to the scale is perpendicular.
4. Find the weight of the block.
5. Slowly pull the panel and measure the force exerted on the scale right before the block starts moving. Also measure the scale during movement.
6. Repeat several times and find the average of the measurements.
7. Repeat the experiment with varying weights, surfaces, and surface areas of the block.
8. Measure the length of the panel.
9. Tilt the panel up and find the height where the block starts sliding.
10. Repeat with varying weights and surfaces.

# 5. Results

## Experiments 1-4

Large contact surface area

Smooth surface

| Experiment # | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| **Type of Surface** | Smooth | Smooth | Smooth | Smooth |
| **Contact Surface Area [$x10^{-3}$ $m^2$]** | 23.46 | 23.46 | 23.46 | 23.46 |
| **Weight [$x10^{-3}$ kg]** | 1184 | 934 | 684 | 434 |
| **Normal Force [$x10^{-3}$ N]** | 11.6 | 9.153 | 6.703 | 4.253 |
| **Maximum Static Frictional Force ($F_0$) [N]** | 2.1 | 1.6 | 1.2 | 0.8 |
| **Kinetic Frictional Force (F') [N]** | 1.5 | 1.2 | 0.9 | 0.5 |
| **Static Frictional Coefficient (Spring Scale) ($\mu$)** | 0.1810 | 0.1748 | 0.1790 | 0.1881 |
| **Kinetic Frictional Coefficient ($\mu'$)** | 0.1293 | 0.1311 | 0.1343 | 0.1176 |
| **H/L** | 0.1230 | 0.1344 | 0.1377 | 0.1393 |
| **$\Theta$** | 7.009 | 7.656 | 7.841 | 7.933 |
| **Static Frictional Coefficient ($\mu=\tan\Theta$) ($\mu$)** | 0.1223 | 0.1344 | 0.1377 | 0.1393 |

## Experiments 5-8

Large contact surface area

Rough surface

| Experiment # | 5 | 6 | 7 | 8 |
|---|---|---|---|---|
| **Type of Surface** | Rough | Rough | Rough | Rough |
| **Contact Surface Area [x$10^{-3}$ $m^2$]** | 23.46 | 23.46 | 23.46 | 23.46 |
| **Weight [x$10^{-3}$ kg]** | 1184 | 934 | 684 | 434 |
| **Normal Force [x$10^{-3}$ N]** | 11.6 | 9.153 | 6.703 | 4.253 |
| **Maximum Static Frictional Force ($F_0$) [N]** | 3.6 | 2.8 | 2 | 1.2 |
| **Kinetic Frictional Force (F') [N]** | 2.4 | 1.7 | 1.6 | 0.8 |
| **Static Frictional Coefficient (Spring Scale) (μ)** | 0.3103 | 0.3059 | 0.2983 | 0.2821 |
| **Kinetic Frictional Coefficient (μ')** | 0.2069 | 0.1857 | 0.2386 | 0.1881 |
| **H/L** | 0.2213 | 0.2541 | 0.2786 | 0.2377 |
| **Θ** | 12.48 | 14.26 | 15.57 | 13.37 |
| **Static Frictional Coefficient (μ=tanΘ) (μ)** | 0.2213 | 0.2541 | 0.2786 | 0.2377 |

## Experiments 9-12

Small contact surface area

Smooth surface

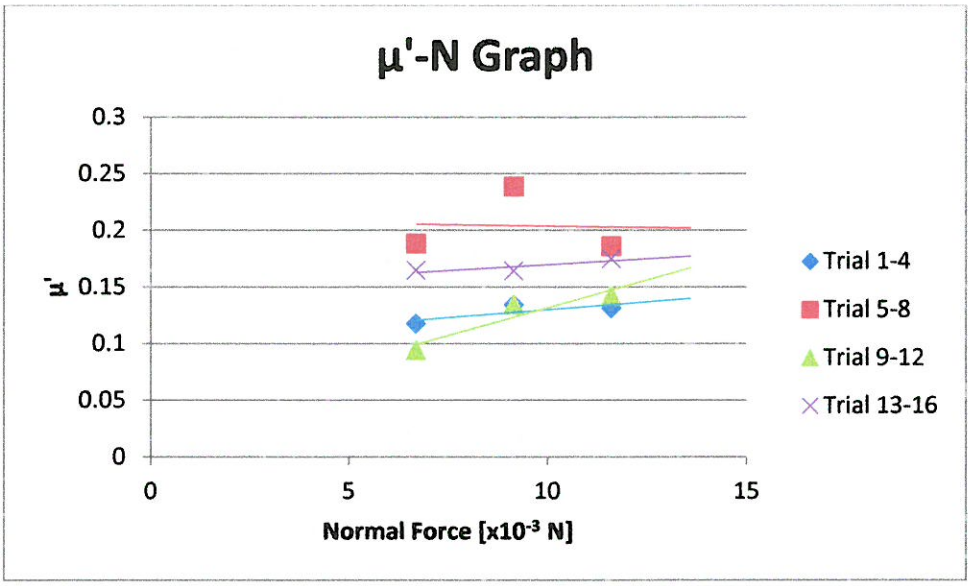
| Experiment # | 9 | 10 | 11 | 12 |
|---|---|---|---|---|
| **Type of Surface** | Smooth | Smooth | Smooth | Smooth |
| **Contact Surface Area [x$10^{-3}$ $m^2$]** | 7.99 | 7.99 | 7.99 | 7.99 |
| **Weight [x$10^{-3}$ kg]** | 1184 | 934 | 684 | 434 |
| **Normal Force [x$10^{-3}$ N]** | 11.6 | 9.153 | 6.703 | 4.253 |
| **Maximum Static Frictional Force ($F_0$) [N]** | 2.2 | 1.7 | 1.2 | 0.6 |
| **Kinetic Frictional Force (F') [N]** | 1.6 | 1.3 | 0.9 | 0.4 |
| **Static Frictional Coefficient (Spring Scale) (μ)** | 0.1896 | 0.1857 | 0.1790 | 0.1411 |
| **Kinetic Frictional Coefficient (μ')** | 0.1379 | 0.1420 | 0.1342 | 0.0941 |

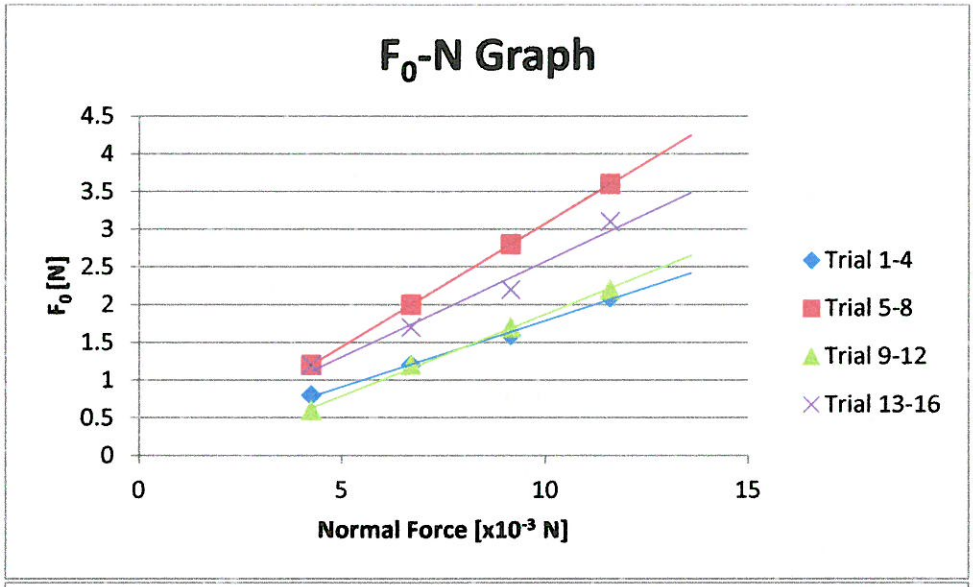
## Experiment 13-16

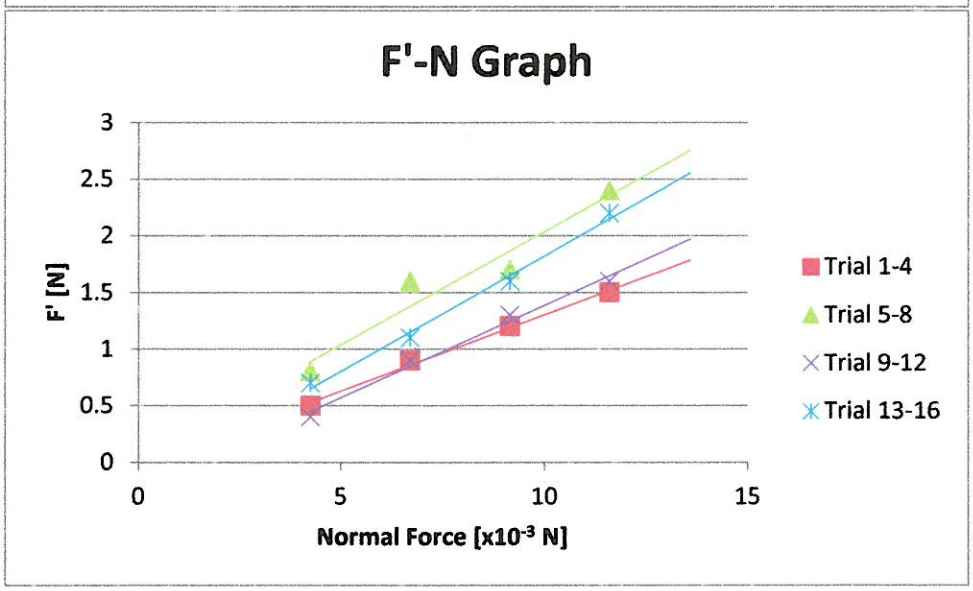
Small contact surface area

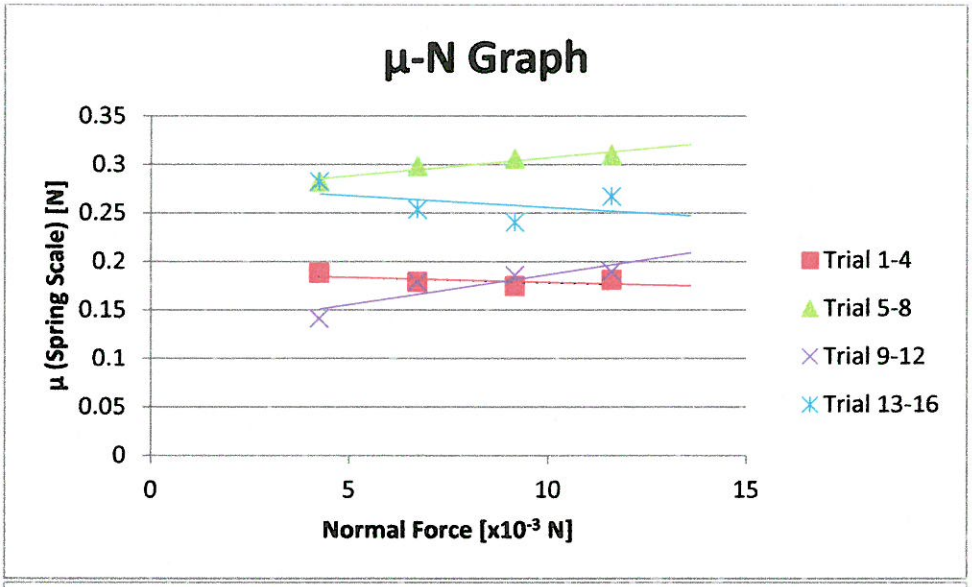
Rough surface

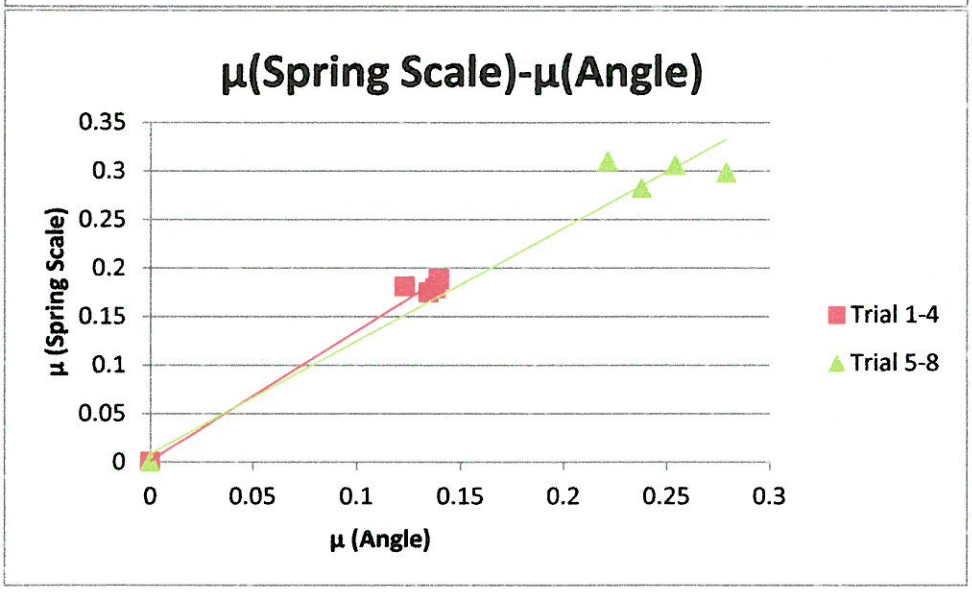
| Experiment # | 13 | 14 | 15 | 16 |
|---|---|---|---|---|
| Type of Surface | Rough | Rough | Rough | Rough |
| Contact Surface Area [$x10^{-3}$ $m^2$] | 7.99 | 7.99 | 7.99 | 7.99 |
| Weight [$x10^{-3}$ kg] | 1184 | 934 | 684 | 434 |
| Normal Force [$x10^{-3}$ N] | 11.6 | 9.153 | 6.703 | 4.253 |
| Maximum Static Frictional Force ($F_0$) [N] | 3.1 | 2.2 | 1.7 | 1.2 |
| Kinetic Frictional Force (F') [N] | 2.2 | 1.6 | 1.1 | 0.7 |
| Static Frictional Coefficient (Spring Scale) (μ) | 0.2672 | 0.2403 | 0.2536 | 0.2821 |
| Kinetic Frictional Coefficient (μ') | 0.1896 | 0.1748 | 0.1641 | 0.1645 |




$F_0$-N Graph
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
$F_0$ [N]
0
5
10
15
Normal Force [x10$^{-3}$ N]
Trial 1-4
Trial 5-8
Trial 9-12
Trial 13-16


F'-N Graph
3
2.5
2
1.5
1
0.5
0
F' [N]
0
5
10
15
Normal Force [x10$^{-3}$ N]
Trial 1-4
Trial 5-8
Trial 9-12
Trial 13-16


μ-N Graph
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
μ (Spring Scale) [N]
0
5
10
15
Normal Force [x10-3 N]
Trial 1-4
Trial 5-8
Trial 9-12
Trial 13-16


μ(Spring Scale)-μ(Angle)
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
μ (Spring Scale)
0
0.05
0.1
0.15
0.2
0.25
0.3
μ (Angle)
Trial 1-4
Trial 5-8

## 6. Discussion

From each of the graphs we can see that the theories we tested in this experiment were valid to a reasonable extent. Both the static and kinetic frictional forces are directly proportional to the weight, and the weight did not have an impact on the coefficients. The coefficients derived from the spring scale and angle had a reasonable amount of difference where it shouldn't have from human error. In this experiment I felt that there were many instances where human error could have greatly influenced the results. Perhaps the experiment would be more accurate using motors to pull the panels.

## 7. Conclusion

Both the static and kinetic frictional forces are directly proportional to the frictional coefficient (roughness) and normal force (weight).

## 8. Opinions

With this experiment I was able to familiarize myself the theorems surrounding friction. Now it feels intuitive that the heavier the object and rougher the surface, friction increases. The part of the experiment where we find the static frictional coefficient by two different methods was a good experience since I got to learn that there is definitely more than one way to derive these values.

## 9. Sources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https://support.office.com/en-us/article/TAN-function-434a3516-6069-4b1d-8aeb-9a3c458adc70?ui=en-US&rs=en-US&ad=US