

THE COPPERBELT UNIVERSITY

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• Title : Coefficients of Static friction

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Due Date : 20th March, 2023

Title : Coefficients of Static friction

Aim : To determine the coefficient of static friction

Apparatus : A horizontal plane, a frictionless pulley fixed at one end, trays with different surfaces, weight box, scale pan, string and mass hanger.

Theory

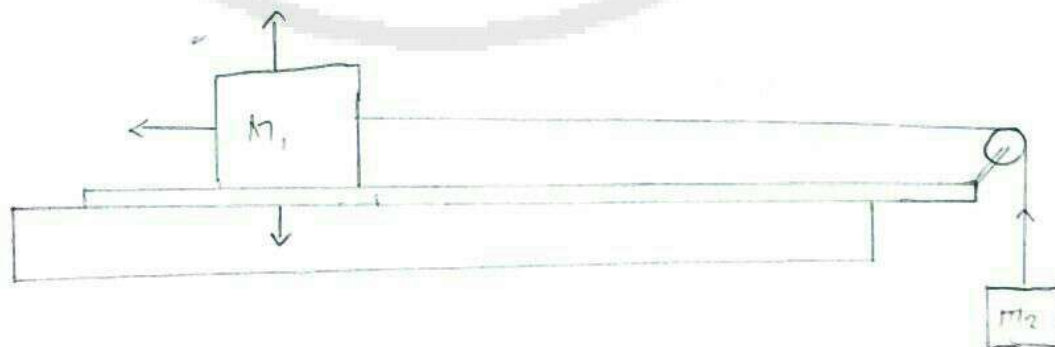
Friction is the resisting force encountered when one tries to slide one surface over another. This force acts along the tangent to the surface in contact. It is found experimentally that the force of friction is directly proportional to the normal force. The constant of proportionality is called the coefficient of friction. When a body lies at rest on a surface and an attempt is made to push it, the pushing force is opposed by a frictional force equal to

$$f = \mu_s F_N \dots \dots (i)$$

Where μ_s is the coefficient of static friction and F_N is the normal force. When the pushing force is greater than the static friction force, the body begins to move. If the contacting surfaces sliding one over the other, the force of friction is given by :

$$f = \mu_k F_N \dots \dots (ii)$$

Here μ_k is the coefficient of kinetic friction.



Procedure

- The mass hanger and wooden surface were weighed separately.
- The mass hanger and wooden surface tray were tied using a 50cm string.
- The wooden surface tray was placed on the horizontal plane at a 30cm mark and allowed the string to pass over the frictionless pulley so that the mass hanger was on the other side below the pulley.
- Weights were added on the mass hanger till the wooden surface began to slide and the weights were noted for two trials.
- The experiment was repeated by adding weights of 50g, 100g, 150g, 200g on top of the wooden surface, each time starting from the 30cm mark.
- Finally, the entire process was repeated using a plastic and wool surfaced trays separately.

Data Collection

Material	Trial	Weight on tray (α) N					Weight on hanger when tray slides				
Wooden Surface tray	1	0	0.49	0.98	1.47	1.96	0.588	1.078	1.372	1.96	2.45
	2	0	0.49	0.98	1.47	1.96	0.686	1.078	1.568	1.96	2.45
Plastic surface tray	1	0	0.49	0.98	1.47	1.96	0.196	0.294	0.392	0.49	0.588
	2	0	0.49	0.98	1.47	1.96	0.196	0.294	0.49	0.588	0.686
Wool Surface tray	1	0	0.49	0.98	1.47	1.96	0.294	0.49	0.588	0.882	1.078
	2	0	0.49	0.98	1.47	1.96	0.294	0.49	0.686	0.882	1.078

Data Analysis

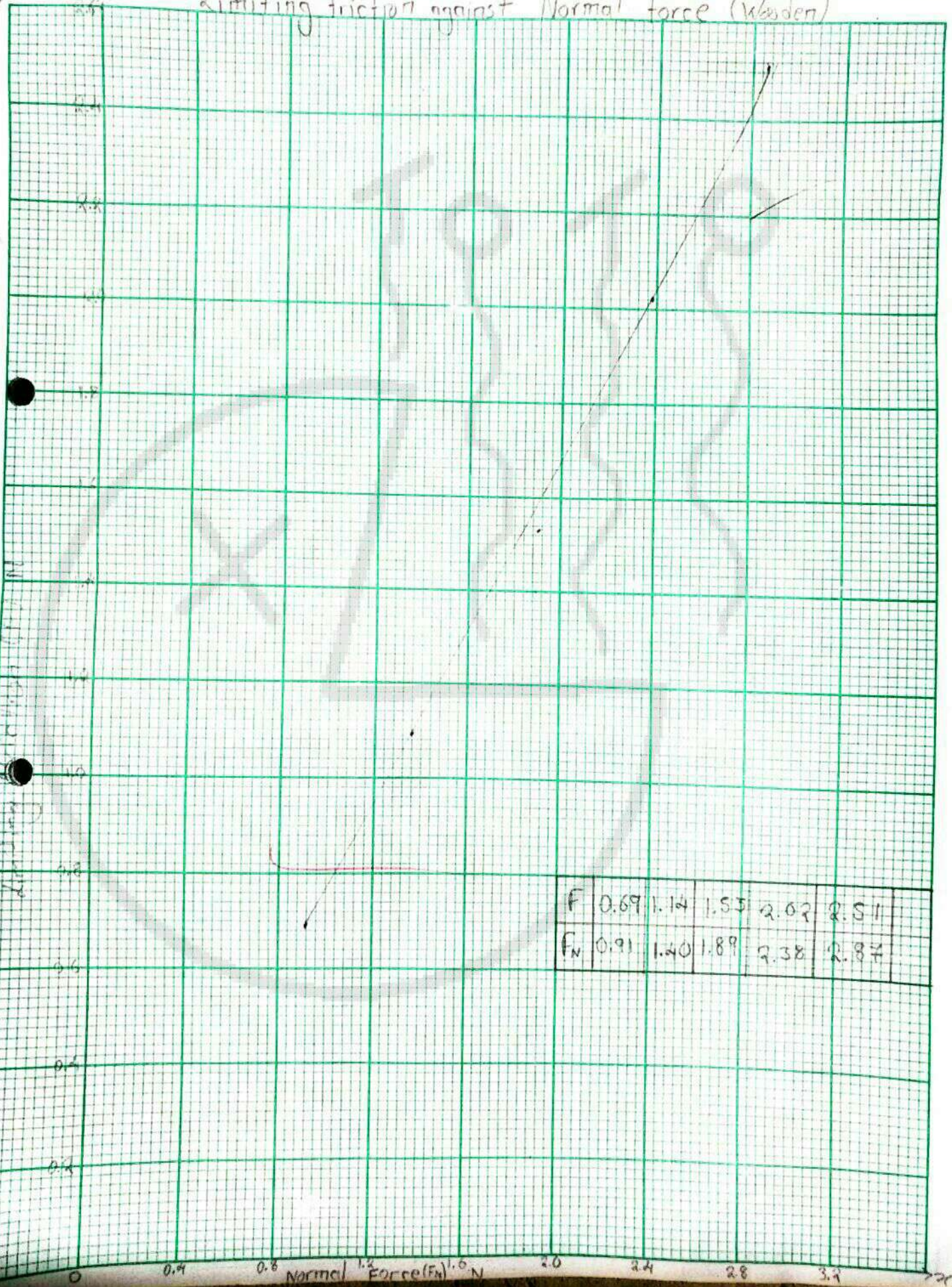
Material/ Surface	Trial	Weight on tray (x) N					Weight on hanger when tray slides (y) N					Limiting Friction $f = (s+y)$					Normal Force $F_N =$ $W + X$					Average coefficient for each weight on the block μ_s				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Wooden Surface tray	1	0	0.49	0.98	1.47	1.96	0.588	1.078	1.392	1.96	2.45	0.646	1.136	1.43	2.018	2.508	0.912	1.402	1.892	2.382	2.872					
	2	0	0.49	0.98	1.47	1.96	0.686	1.508	1.96	2.45	2.94	1.136	1.626	2.018	2.508	2.998	0.912	1.402	1.892	2.382	2.872					
	3	0	0.49	0.98	1.47	1.96	0.784	1.608	2.018	2.508	2.998	1.234	1.724	2.116	2.606	3.096	0.912	1.402	1.892	2.382	2.872					
	4	0	0.49	0.98	1.47	1.96	0.882	1.708	2.118	2.608	3.098	1.332	1.822	2.214	2.704	3.194	0.912	1.402	1.892	2.382	2.872					
	5	0	0.49	0.98	1.47	1.96	0.98	1.808	2.218	2.708	3.198	1.43	1.92	2.312	2.802	3.292	0.912	1.402	1.892	2.382	2.872					
Plastic Surface tray	1	0	0.49	0.98	1.47	1.96	0.196	0.294	0.49	0.588	0.686	0.254	0.352	0.45	0.548	0.646	0.914	1.404	1.894	2.384	2.874					
	2	0	0.49	0.98	1.47	1.96	0.294	0.392	0.49	0.588	0.686	0.352	0.45	0.548	0.646	0.744	0.914	1.404	1.894	2.384	2.874					
	3	0	0.49	0.98	1.47	1.96	0.392	0.49	0.588	0.686	0.784	0.45	0.548	0.646	0.744	0.842	0.914	1.404	1.894	2.384	2.874					
	4	0	0.49	0.98	1.47	1.96	0.49	0.588	0.686	0.784	0.882	0.548	0.646	0.744	0.842	0.94	0.914	1.404	1.894	2.384	2.874					
	5	0	0.49	0.98	1.47	1.96	0.588	0.686	0.784	0.882	0.98	0.646	0.744	0.842	0.94	1.038	0.914	1.404	1.894	2.384	2.874					
Wood Surface tray	1	0	0.49	0.98	1.47	1.96	0.299	0.49	0.588	0.686	0.784	0.352	0.45	0.548	0.646	0.744	0.831	1.321	1.811	2.301	2.791					
	2	0	0.49	0.98	1.47	1.96	0.399	0.49	0.588	0.686	0.784	0.45	0.548	0.646	0.744	0.831	0.918	1.321	1.811	2.301	2.791					
	3	0	0.49	0.98	1.47	1.96	0.499	0.49	0.588	0.686	0.784	0.548	0.646	0.744	0.831	0.918	0.999	1.321	1.811	2.301	2.791					
	4	0	0.49	0.98	1.47	1.96	0.599	0.49	0.588	0.686	0.784	0.646	0.744	0.831	0.918	1.009	0.999	1.321	1.811	2.301	2.791					
	5	0	0.49	0.98	1.47	1.96	0.699	0.49	0.588	0.686	0.784	0.744	0.831	0.918	1.009	1.109	0.999	1.321	1.811	2.301	2.791					

ZAMBIA STANDARD GRAPH PAPER

Name.....

Examination Number.....

Limiting friction against Normal force (Wooden)



ZAMBIA STANDARD GRAPH PAPER

Name

Examination Number

0.72 Limiting Reaction against Normal Force (Woa)

0.66

0.6

0.54

0.48

0.42

0.36

0.3

0.24

0.18

0.12

0.06

0

0.4

0.8

1.2

1.6

2.0

2.4

2.8

3.2

3.6

F	0.25	0.35	0.49	0.59	0.69
F_N	0.91	1.40	1.89	2.38	2.87

ZAMBIA STANDARD GRAPH PAPER

Name.....

Examination Number.....

Limiting friction against Normal force (w/ool)

Normal force (N)



f	0.35	0.55	0.69	0.94	1.36
f_N	0.831	1.32	1.811	2.501	2.77

Normal force (f_N) N

From the Slope

Wooden surface tray

$$\begin{aligned} m &= \frac{\Delta y}{\Delta x} \\ &= \frac{0.02 - 1.14}{0.38 - 1.40} \\ &= \frac{0.88}{0.98} \\ &= \underline{\underline{0.89}} \end{aligned}$$

Plastic surface tray

$$\begin{aligned} m &= \frac{\Delta y}{\Delta x} \\ &= \frac{0.35 - 0.25}{1.40 - 0.91} \\ &= \frac{0.1}{0.49} \\ &= \underline{\underline{0.204}} \end{aligned}$$

Wool surface tray

$$\begin{aligned} m &= \frac{\Delta y}{\Delta x} \\ &= \frac{0.55 - 0.35}{1.391 - 0.831} \\ &= \frac{0.2}{0.49} \\ &= \underline{\underline{0.408}} \end{aligned}$$

\therefore the values obtained from the graph are typically the same as those average values calculated from the table 2.

Discussion

On analysing coefficients of static friction, several trials were carried out so as to come up with an average value. The coefficient of static friction was calculated by dividing the normal force into the friction force. The coefficient of wooden, plastic and wool surface tray were found to be 0.873, 0.241, 0.408 respectively.

Conclusion

The objective of the experiment was achieved as the coefficient of static friction of wood, plastic and wool were determined. In addition, the experiment showed that the amount of force required to move objects with different surfaces varies. Furthermore, rough surfaces have a higher static friction than smooth surfaces.

Reference

PH110 lab manual (2022-23), School of Mathematics and Natural Sciences, Dept of physics.