Practical-4

Friction on a surface and an inclined plane

Name- Satvik Sharma

Student ID -218595095

Unit- engineering physics

Unit code -SEB101

Group members- Zac Brydon

Vilanya Ratnayake

Jude Zhu

Yinhao Chen

Tom Hunt

Session Date- 12/04/2019

Submission Date- 19/04/2019

Reports

Aim

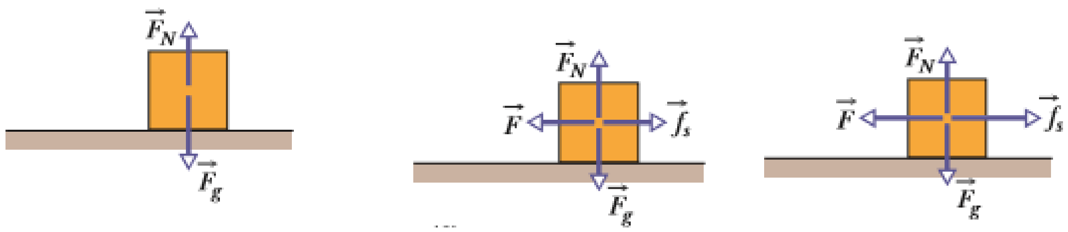
The aim of this experiment is to find the coefficient of friction for a plane track (coefficient of static friction) and a track at a certain angle (coefficient of kinetic friction). Also determining the difference in the friction for the two surface one being the smooth and other one rough.

Introduction

Initially when the force is applied to the block it does not move. Gradually the force being applied is increased and after a certain point it gets to the maximum force. Up to this point, it is static friction that is acting up, and formula for the maximum static frictional force is given by

$F_s=\mu_s N$ ...(i)

Where F_s is the static force, μ_s is the coefficient of static friction and N is the normal force.

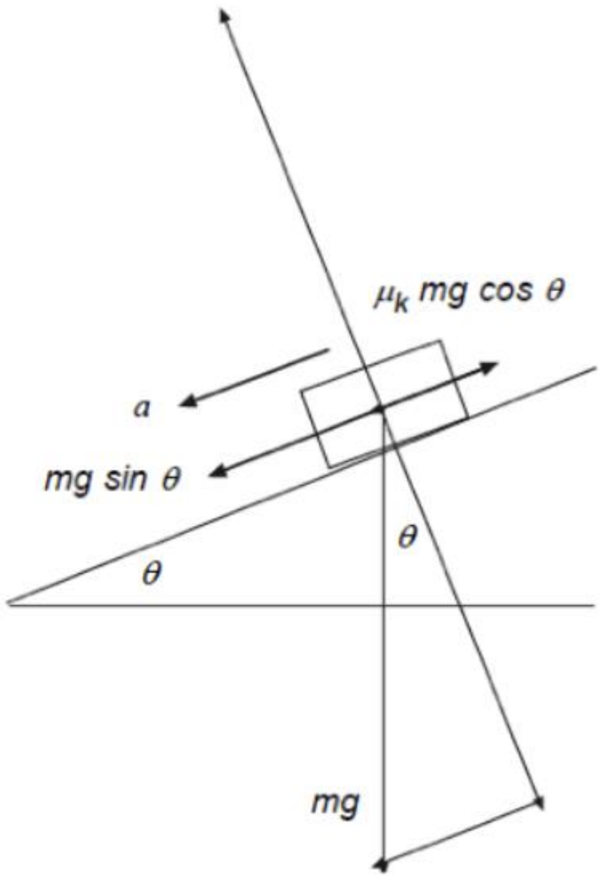


As the force is increase the static friction also increase and at maximum these two forces are balanced out. Afterwards the block starts moving and this leads to the birth of a new kind of friction known as kinetic friction. Its formula is denoted below

$F_k = \mu_k N$ ...(ii)

Where F_k is the static force, μ_k is the coefficient of static friction and N is the normal force. Since the force applied is more than the frictional force, this means that the frictional force opposes the applied force in opposite direction.

When the block is placed on an inclined plane, the gravitational force acts is the moving agent instead of the applied force.



According to above diagram, when the plane is inclined at a certain angle the block starts moving down, meaning that it is in motion under the act of gravity and the necessary frictional force provided by plane to the block is $\mu_k$mgCosθ. This means that the net force acting on the body is

F_{net}=mgSinθ- $\mu_k$mgCosθ ...(iii)

If F=ma, this leads to

ma= mgSinθ- $\mu_k$mgCosθ

or

μ_k=Tanθ-(a/gCosθ) ...(iv)

this is the friction provided by the inclined plane.

Experiment method

Part A:

1. Two kinds of carts are taken, one with the cork base and the other one smooth base. These two kinds of cart are attached to the force sensor and the force sensor is connected to a GLX which is recording all the data.
2. The graph is created on GLX with time on X-axis and force on Y-axis.
3. Weigh the cart and add it to 250 grams and then place it on the surface.
4. Start recording the data. Pull the force sensor gently along the horizontal surface.
5. Observe the graph.
6. Repeat the experiment with 500 grams and 750 grams.
7. Also repeat the experiment on a different surface such as paper towel.

Part B:

1. Keep the tray with 500 grams in it on the plane, and increase the angle of the plane so that the tray slides of at the minimum angle possible.
2. Set up the motion sensor and data logger so that the velocity of the tray will be recorded as a function of time.
3. Complete three trials for the experiment.
4. Repeat the process for the other cart with different base.

Results and calculations

Part A:

weight of smooth cart is 92.3grams

weight of cork cart is 90.4 grams

1. Smooth 250 grams plane surface.

Run	F_s	F_k	N	μ_s	μ_k
1	0.4	0.1		1.16	0.29
2	0.8	0.4	0.3423	2.33	1.16

3	0.5	0.1		1.46	0.29
average	0.5	0.2		1.65	0.58
uncertainty	0.2	0.1	0	0.58	0.43

2. Smooth 500 grams plane surface

Run	F_s	F_k	N	μ_s	μ_k
1	1.2	0.5		2.03	0.84
2	1.2	0.6	0.5923	2.03	1.01
3	1.5	0.3		2.54	0.50
average	1.3	0.4		2.2	0.78
uncertainty	0.1	0.1	0	0.25	0.25

3. Smooth 750 grams plane surface

Run	F_s	F_k	N	μ_s	μ_k
1	1.3	0.4		1.54	0.47
2	2.0	0.5	0.8423	2.38	0.59
3	1.8	0.4		2.14	0.47
average	1.7	0.4		2.02	0.51
uncertainty	0.35	0.05	0	0.42	0.06

4. Cork 250 grams plane surface

Run	F_s	F_k	N	μ_s	μ_k
1	0.9	0.3		2.64	0.88
2	1.1	0.3	0.3404	3.23	0.88
3	0.9	0.3		2.64	0.88
average	0.9	0.3		2.83	0.88
uncertainty	0.1	0	0	0.29	0

5. Cork 500 grams plane surface

Run	F_s	F_k	N	μ_s	μ_k
1	2.6	1.3		4.4	2.2
2	2.7	1.0	0.5904	4.5	1.6
3	2.7	1.4		4.5	2.3
average	2.6	1.2		4.4	2.03
uncertainty	0.05	0.2	0	0.05	0.35

6. Cork 750 grams plane surface

Run	F_s	F_k	N	μ_s	μ_k
1	3.3	1.3		3.92	1.54
2	2.9	1.1	0.8404	3.45	1.30
3	2.3	0.8		2.73	0.95
average	2.8	1.0		2.52	1.26
uncertainty	0.5	0.25	0	0.59	0.29

7. smooth 250 grams rough(towel) surface

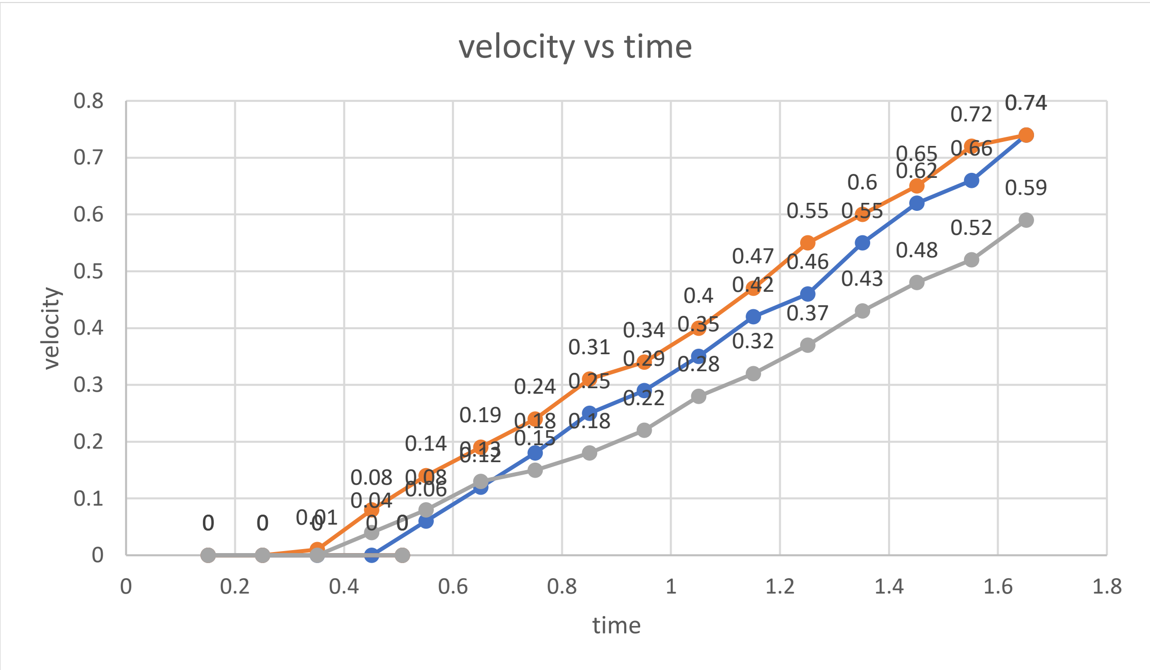
Run	F_s	F_k	N	μ_s	μ_k
1	1.5	0.7		4.4	2.05
2	1.5	0.3	0.3423	4.4	0.88
3	1.7	0.6		5	1.76
average	1.5	0.5		4.6	1.56
uncertainty	0.1	0.2	0	0.3	0.58

8. Cork 250 grams rough(towel) surface

Run	F_s	F_k	N	μ_s	μ_k
1	0.5	0.2		1.47	0.58
2	0.4	0.1	0.3404	1.17	0.29
3	0.4	0.1		1.17	0.29
average	0.4	0.1		1.27	0.38
uncertainty	0.05	0.05	0	0.15	0.14

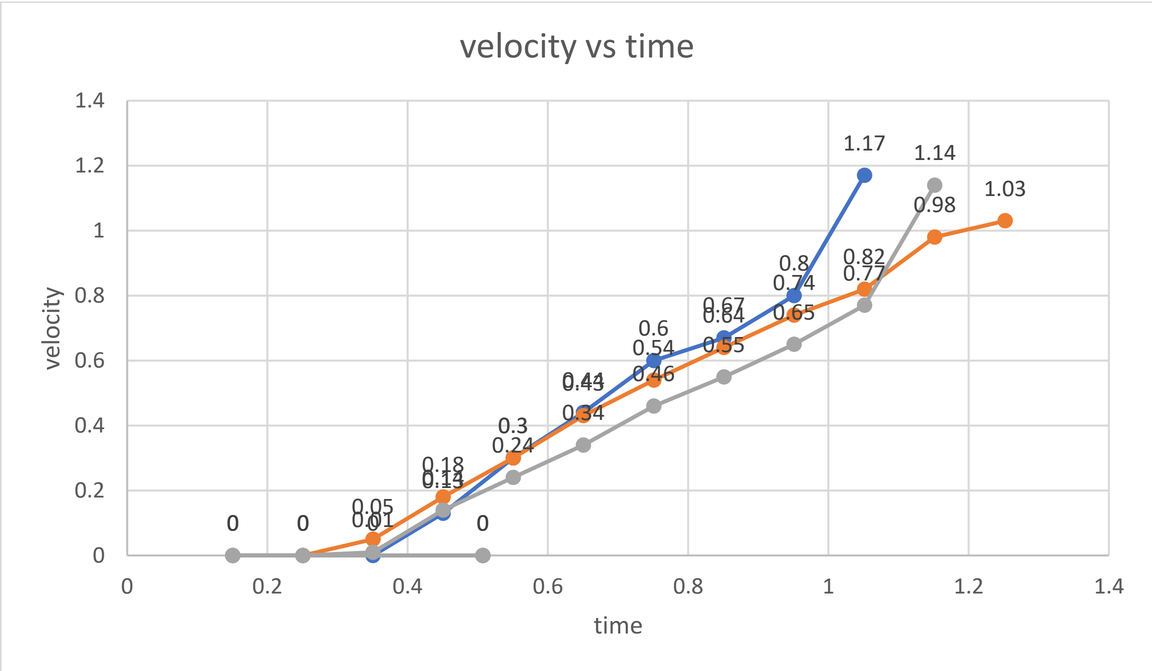
Part B: Plane at angle

1. Graph for smooth surfce



Run	Angle	Acceleration	μ_k
1		0.44	0.25
2	4	0.44	0.25
3		0.35	0.33
average		0.41	0.27
uncertainty		0.04	0.04

2. Graph with cork base



Run	Angle	Acceleration	μ_k
1		1.11	0.340
2	25	0.98	0.355
3		0.82	0.373
average		0.97	0.356
uncertainty	0	0.14	0.016

Discussions

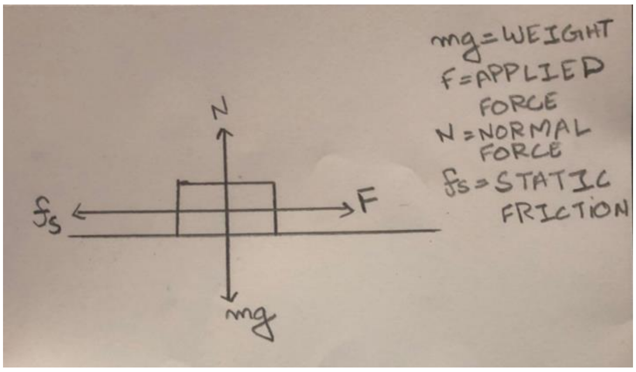
For the horizontal surface, the force increases gradually upto a certain extent which is known as force of static friction. Afterwards the force decreases when it starts to move and it starts to maintain a constant friction which is the force of kinetic friction.

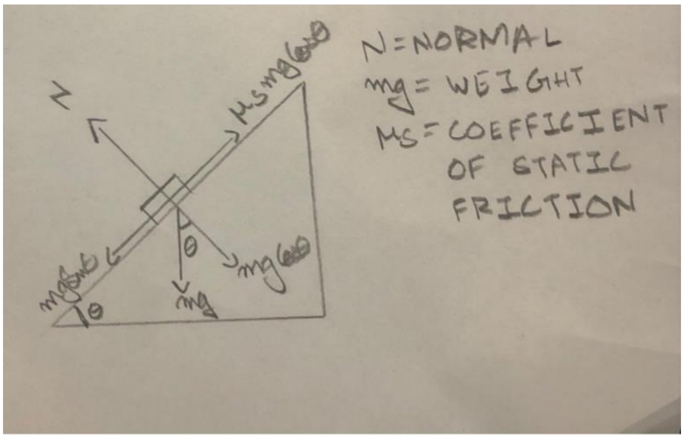
For the inclined surface, the angle of plane is increase upto a certain extent. This means that the body maintains a static friction and as soon as the force of gravity overcomes, the body starts moving down and is opposed by the force of kinetic friction.

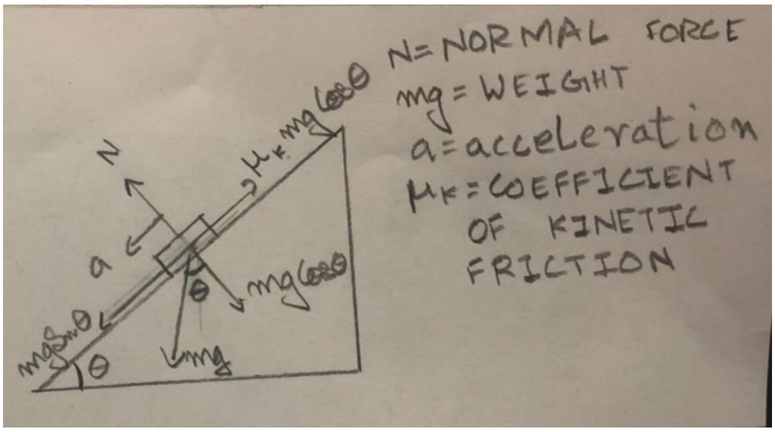
The difference in the surfaces also increases the frictional force. This is seen from the practical using the smooth and cork surface and then doing the process on the paper towel. According to it the minimum friction is between the smooth tray and smooth surface and maximum is between the cork surface and paper towel.

Conclusions

1. Free body diagrams







2. Comparing the coefficients of friction.

Smooth suface(500 grams)

μ_s	μ_k horizontal	μ_k inclined
2.03	0.84	0.25
2.03	1.01	0.25
2.54	0.50	0.33

Cork base(500 grams)

μ_s	μ_k horizontal	μ_k inclined
4.4	2.2	0.340
4.5	1.6	0.355
4.5	2.3	0.373

3. The mass of the tray is not included when the acceleration is calculated because when going down, the relation used is
   $F=mgSin\theta- \mu_k\ mgCos\theta$
   Which on further solving gives the result
   $\mu_k=Tan\theta-(a/gCos\theta)$

References

- Deakin university, SEB101 lab manual 2019.
- Halliday, Resnik & Walker 2003, *Fundamentals of Physics*, 10th edn, Wiley plus