

Force of friction essay sample



**ASSIGN
BUSTER**

1. Objective

1. To study the effects of the normal reaction and surface area on the force of friction using a block.
2. To estimate and compare the coefficients of static and kinetic friction of different materials.

2. Apparatus

- * Wooden block (190. 0 g) 3
- * Elastic strings
- * Wooden plank 1
- * Spring balance 1
- * Plastic plate 1
- * Balance 1
- * Brick 1

3. Theory

Limiting static friction

Friction always opposes motion. It increases with the applied force. However, it cannot increase indefinitely.

When a body is in contact with a rough surface, friction arises at the contact surface if the body is subjected to an applied force. When the applied force

exceeds the limiting static friction, the body will start to slip over the rough surface. And the value of f_s is roughly proportional to the normal reaction R .

where μ_s is the coefficient of static friction at the contact surface.

Kinetic friction

Generally, the friction acting on a resting block is less than until the block starts to move. Once the body starts to move over the rough surface, the friction would decrease slightly to a value known as kinetic friction. So μ_k is slightly less than μ_s but it is still approximately proportional to R .

Where μ_k is the coefficient of kinetic friction at the contact surface.

Remains constant even the applied force is increased further.

μ_k is slightly less than μ_s .

3. Procedure

A. Effect of applied force on friction

1. The set up is connected as shown below.
2. Slowly push the wooden plank (together with the trolley underneath) away from the spring balance. Note the increase in the spring balance's reading which indicates the static friction. When the block starts to slide, quickly read the spring balance. This maximum value is the limiting static friction. Keep pushing the wooden plank to maintain a steady sliding, and note again the spring balance's reading which now indicates the kinetic friction.

3. Repeat the measurement of and few more times to get the average values.

B. Coefficients of friction for various materials

4. Add 1 block (totally 2 blocks) onto the original one. Repeat step 2.

5. Add 1 more block (totally 3 blocks). Repeat step 2.

6. Replace the wooden plate with the plastic plate and brick respectively.

Use the same face of the wooden block. Repeat step 2 to 5.

C. Effect of surface area on friction

7. Place the wooden blocks onto the wooden plank side by side instead of piling up. Then connect them to the spring balance and move the trolley until they slide. Note the readings.

8. Repeat step 7 with 3 blocks.

4. Data Analysis

A. Effect of applied force on friction

Block without sliding:

1

2

3

4

5 (just before sliding began)

Reading / N

0. 1

0. 2

0. 5

0. 8

1. 1

Block sliding:

1

2

3

4

5

Reading / N

0. 4

0. 5

0. 4

0.3

0.4

Therefore, for a wooden block on a wooden plank, the limiting static friction is 1.1 N.

B. Coefficients of friction for various materials

Wood on wooden plank:

Number of blocks

1

2

3

/ N

1.1

2.0

3.2

/ N

0.4

1.1

1.5

R / N

1. 86

3. 73

5. 59

Wood on plastic plate:

Number of blocks

1

2

3

/ N

0. 9

1. 6

2. 3

/ N

0. 3

0. 8

1. 1

R / N

1. 86

3. 73

5. 59

Wood on brick:

Number of blocks

1

2

3

/ N

2. 2

4. 6

6. 5

/ N

1. 2

2. 2

3. 4

R / N

1. 86

3. 73

5. 59

The coefficient of friction of the wooden blocks on various materials are summarized as follow:

wooden plank

plastic plate

brick

0. 57

0. 43

1. 2*

0. 27

0. 21

0. 6

* It is abnormal for the coefficient greater than 1. Refer to the Discussion on page 7.

C. Effect of surface area on friction

Number of blocks

2

3

Pile up

Side by side

Pile up

Side by side

Applied force F / N

(kinetic friction)

1. 1

1. 3

1. 5

1. 8

Normal reaction

R / N

3. 73

3. 73

5. 59

5. 59

5. Errors and Accuracy

The error of measurement of mass of blocks is .

The error in taking reading of spring balance is .

The error in adjusting the position of the scale of the balance is also .

Hence the total error in measuring the force is .

6. Discussion

Assumptions

1. The elastic strings have no mass.
2. Acceleration due to gravity (g) is taken as 9.81 ms^{-2} . Actually it varies in different position on Earth.
3. The block and the plank slide horizontally.

Random and Systematic Errors

Systematic errors include measuring mass of blocks (due to inaccuracy of the electronic balance) and the force (due to inaccuracy of the spring balance).

Suggestions for Improvements

1. Since the elastic strings actually have mass. We can improve the accuracy by two ways:

(a) Count one half of the mass of the strings into the total reaction force (the another half is supported by the balance, not the blocks).

(b) Use blocks with greater mass (e. g. lead blocks). The effect of mass of strings become practically negligible.

2. Determine the actual value of acceleration due to gravity (g).

Abnormal Behavior

The degree of roughness throughout the brick surface was not constant. It was very difficult to keep the force constant.

Comparison of Experimental with Expected Result

A. Effect of applied force on friction

Static friction increased with applied force. It remained stationary relative to the wooden plank. Until limiting static friction (f_s) was reached, the block began to slide and the reading (representing f_s) remained basically constant.

Experimental value of f_s is much smaller than f_s . Theoretically, f_s should be only slightly smaller than f_s . This may be to error. If heavier blocks are used, the difference between f_s and f_s might be smaller.

B. Coefficients of friction for various materials

Coefficients (both and μ): plastic plate < wooden plank < brick. By common sense, brick is the roughest and plastic is the smoothest. The experimental results prove our assertion. Also, experimental value of μ is much smaller than μ_s . Refer to the above explanation.

All graphs are straight lines passing through the origin. This result tells us both limiting static friction and kinetic friction are directly proportional to the reaction force.

* The coefficient of static friction of brick is 1.2, greater than 1. This was because the brick surface was too rough that it was actually not a flat surface. Additional force is required to move the block up and down. The motion was not sliding at all. Therefore the theory of $0 < \mu < 1$ does not hold in this case.

C. Effect of surface area on friction

Theoretically, friction is independent of contacting area. The result should be the same when the blocks are arranged side by side and piled up. However experimental results show that friction when side by side is slightly greater than that when piled up. This may be due to varying degree of roughness throughout the contacting surface. Increase of contacting area increases chance of experiencing more uneven roughness. This will result in greater fluctuation of frictional force and thus greater experimental error.

7. Answers to Worksheet Questions

Q. 16 What is/are the advantage(s) of pulling the wooden plank, instead of pulling the wooden block with the spring balance, in the measurement of and ? Discuss the physical meaning of the spring balance's reading in each case.

A. 16 It make sure the blocks are experiencing constant applied force. If they were pulled by the spring balance directly, it was difficult to keep the force constant. Then the change in force will be used to accelerate to blocks, instead of just balancing the frictional force.

Also, we can ensure the applied force is horizontal by fixing the spring balance on a horizontal platform. If we pull the spring balance directly, the force may not be always horizontal and the useful horizontal component of the force will be smaller than the balance's reading.

When pulling the plank, the spring balance's reading represents the frictional force. When pulling the blocks directly, the reading represents the applied force, which may not be equal (in magnitude) to the friction.

Q. 17 In pushing a car (with the engine detached from the wheels), explain briefly why it is more difficult to start the motion, but once the car is moving, it is relatively easier to maintain its motion.

A. 17 Limiting static friction is greater than kinetic friction. Especially for a car with mass generally over 1000 kg, the reaction force is very large. So the difference of magnitude between these two types of friction is very significant for a human.

Q. 18 In the design of the braking system in bicycles, what parameter(s) should be maximized to achieve a larger frictional force?

A. 18 The reaction force exerted on the braking pads and the coefficient of kinetic friction should be maximized.

8. Conclusion

This experiment was quite successful. It demonstrated that friction is directly proportional to normal reaction but independent of contacting area. Also, coefficients of static and kinetic friction can be compared.