Name:____________________ ID No.:______________ Date: ______

Section: ___________________ Score: _______________

Preparatory Physical Science (PHSC001)

Experiment No. 4

Friction Analysis

Objectives

- To be familiar with static and kinetic friction.
- To be familiar with the concept of uniform motion and its condition.

Key Terms:

Normal force
Frictional force
Static and kinetic frictional forces
Coefficient of static and kinetic friction

Theory

When an object (a book for example) is in contact with a surface (tabletop for example), there is a force acting on this object that makes an angle with the surface. One component of this force is called the ***normal force***, which acts perpendicularly on the surface. When the object moves or tries to move along the surface, there is an also another component of that force that act on the object and is parallel to the surface. This parallel force is called the ***frictional force***. It is a force, which acts to oppose/resists any change in motion [zero (at rest) or non zero (motion)].

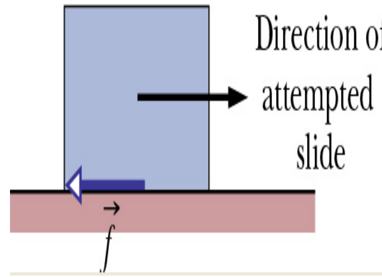
The surface of any solid object like the tabletop no matter how smooth it may looks is quite rough on a microscopic level. It is full of bumps (irregularities) that resist the motion (sliding or rolling) of any other object in contact with it. This resistance is represented by friction force. The contact between the two solid surfaces, indeed, creates a bonding between the bumps of each.

Any medium not necessary a solid exhibits resistance to a certain extent; air for example resists the motion of all thrown and flying objects. Liquids like water offer some resistance too. In this lab, we will work with solids in contact.

The friction force is a reaction force; therefore it follows from Newton's third law that if there is no applied force tending to slide the object there is no friction.

Referring to Figure 4.1, this shows an object initially at rest and placed on a tabletop. Let F be the force, which tends to cause the object to slide on the tabletop. Let F_N be the normal force (not shown in Figure (4.1)) supplied by the table (in this case F_N equals the weight of the object). Figure (4.1) shows also the friction force f that acts at the boundary between the two surfaces and is opposite in direction to F .

If F is zero, f is also zero. As F is increased, f increases also, and as long as the object does not slide the condition $F = f$ applies. If the applied force F continuous to increase, there comes a point when the object finally "breaks away" and begins to slide. The force just before breakaway represents the maximum ***static frictional force*** $f_{s,\max}$ and is given by



$$f_{s,max} = \mu_s F_N \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4.1)$$

Figure 4.1: Two surfaces in contact showing the force of friction f .

Where μ_S is ***the coefficient of static friction***. It was found by experiment that once the object starts moving, that f_s is reduced to a lower value called ***kinetic frictional force*** f_k given by

$$f_k = \mu_k F_N \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4.2)$$

Where μ_k is ***the coefficient of kinetic friction***. In this lab, you will experimentally determine and compare both static and kinetic frictional forces and their coefficients.

Materials

- Friction block the with a hook
- Spring balance, 1N
- Slotted weights, 50 g
- Paper
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To compare and determine both static and frictional forces

Method

1. Use the 1N spring to weigh the friction block. Place the friction block (object) with its smooth surface on the tabletop as shown in Figure (4.2).
2. Place the block on the tabletop, smooth surface in contact with tabletop. For good results, place a 50 g weight on top of the block. Make sure the block's hook is in an upward direction.
3. Attach the 1N spring to the block's hook and pull slowly until the moment has reached when the block is on the verge of sliding. Make sure the system (block and spring) is on a horizontal position all times.
4. Repeat step 3 and watch the spring's indicator and the block at the same time. Measure $f_{s,max}$at the moment the block breaks away.
5. Keep pulling slowly to assure that the block is moving with a constant aped.
6. Now you observed that $f_{s,max}$is lowered tof_k. Keep the constant pull to allow for constant speed and measuref_k.
7. Repeat steps 1-4 for another measurements of both frictional forces. Record your findings in Table 1.
8. Place the block on a regular paper and repeat steps 1- 6. Record your findings in Table 2.

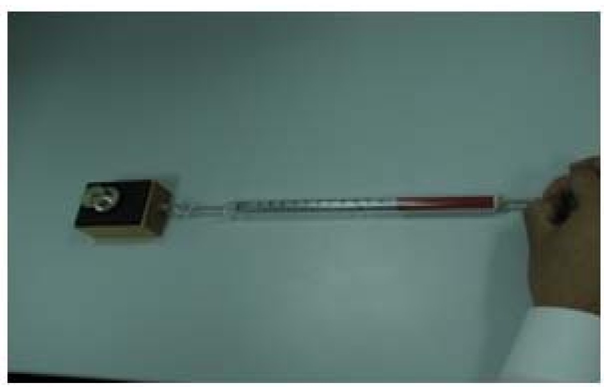

Figure (4.2): Top view of Lab 4 setup. The block is on a smooth surface (tabletop)

Table 1: Block is on the smooth surface

Block's weight + (50 x 10^{-3}) (9.8m/sec^2) = W = ……………. N

Static frictional force $f_{s,max}$ (N)		Kinetic frictional force f_k (N)		Average (N)		F_N = W (N)	μ	
Trial 1		Trial 2		$f_{s,max}$	f_k		μ_s	μ_k
Trial 2		Trial 2						

Table 2: Block is on rough (paper) surface

Block's weight + (50 x 10^{-3}) (9.8m/sec^2) = W = ……………. N

Static frictional force $f_{s,max}$ (N)		Kinetic frictional force f_k (N)		Average (N)		F_N = W (N)	μ	
Trial 1		Trial 2		$f_{s,max}$	f_k		μ_s	μ_k
Trial 2		Trial 2						

Questions:

1. Why is it necessary that the block be moving with uniform (constant) speed in determining the force of kinetic friction?

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2. A horizontal force of 100 N is required to push a piece of furniture across a floor at constant velocity.

   (a) What is the net force acting on the furniture?

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   (b) How much is the friction force that acts on the sliding furniture?

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   (c) How much friction acts on the furniture when it is at rest on a horizontal surface?

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References

1. **The PHWE- Document Series Mechanic Part 1-5.**
2. **Norman C. Harris, "experiments in applied physics", McGraw-Hill company, 1972.**
3. **D. C. Giancoli, " Physics, principles with applications", 5th Ed, Prentice Hall, 2008.1998.**
4. **D. Haliday, R. Resnick, and J. Walker, " Fundamentals of physics", 8th Ed.,**

<u>**End of the Lab Exercise**</u>