MND Physics

Coefficient of Kinetic Friction Lab

When a block rests on an inclined plane, its weight F_g which is assumed to be concentrated at the center of gravity of the block, acts vertically downward. Since the block cannot move in that direction, the weight of the block must be resolved into 2 component forces. One component F_{gx} acts parallel to the plane and tends to slide the block down the plane. The other component F_{gy} acts at a right angle to the plane and is the force that holds the block down on the plane.

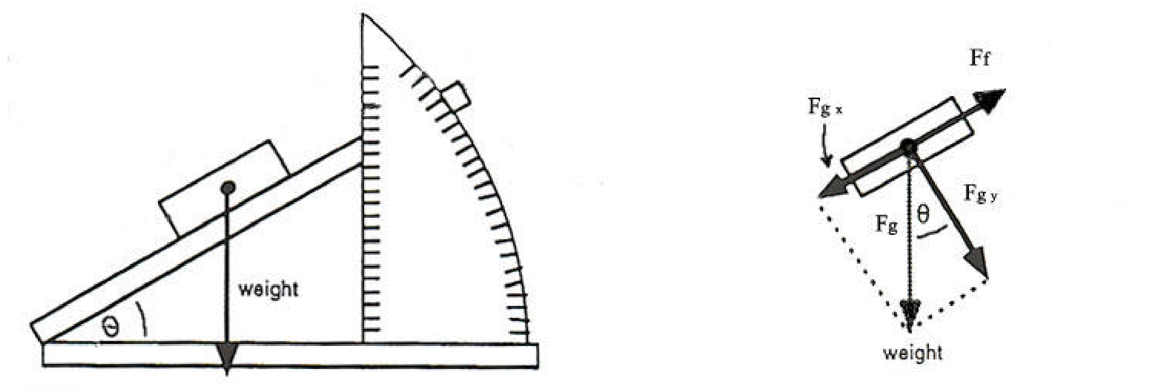
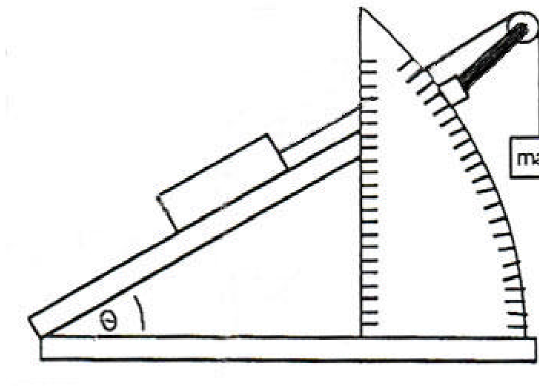


Diagram 1

First, consider the arrangement (Diagram 1) where a wood block slides down an inclined plane with uniform speed i.e. no acceleration. When the slope of the plane is exactly set to cause the block to slide down at a uniform speed, the ratio of the parallel force F_{gx} to the perpendicular force F_{gy} is the coefficient of kinetic friction between the block and the plane. Since, in this case, F_{gy} is equal to the normal force F_N, and F_{gx} is equal to the frictional force F_f, we can say

$\mu_k = F_f / F_N$ or re-arranging, $\boxed{\mu_k = F_{gx} / F_{gy}}$



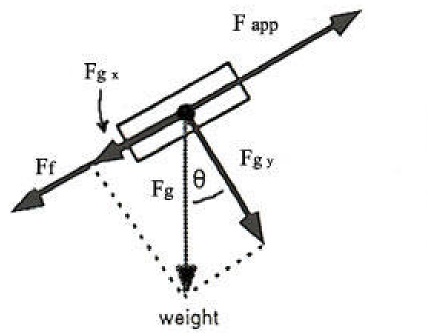


Diagram 2

Now consider the case of the wood block sliding UPWARD at a uniform speed by the introduction of an applied force (Diagram 2); the applied force is generated by weight hung over the top of the inclined plane (this weight is attached to the wood block by a string placed over a frictionless pulley). In this special arrangement, the applied force, $F_{\mathbf{Applied}}$ is equal to the frictional force, $F_{\mathbf{f}}$ PLUS the x-component of gravity $F_{\mathbf{gx}}$. That is, we can say

$$F_{\mathbf{Applied}} = F_{\mathbf{gx}} + F_{\mathbf{f}} \quad \text{or re-arranging,} \quad F_{\mathbf{f}} = F_{\mathbf{Applied}} - F_{\mathbf{gx}}$$

In the "y" direction, $F_{\mathbf{gy}}$ is still equal to the normal force $F_{\mathbf{N}}$, or

$$F_{\mathbf{N}} = F_{\mathbf{gy}}$$

When the weight is exactly set to cause the block to slide UPWARD at a uniform speed, the coefficient of kinetic friction can be calculated as follows:

$$\mu_k = F_{\mathbf{f}} / F_{\mathbf{N}}$$

and substituting, we have

$$\boxed{\mu_k = (F_{\mathbf{Applied}} - F_{\mathbf{gx}}) / F_{\mathbf{gy}}}$$

EQUIPMENT: Adjustable inclined plane, wooden block, string, mass set.

PROCEDURE:

Find the weight of the wood block.

- ## <u>PART 1: Wood block sliding downward</u>

TRIAL 1

Starting from a small angle of inclination, gradually increase the slope of the plane until the wood block slides down at a <u>constant or uniform velocity</u>; you must overcome static friction by giving the block a slight push to start it moving; if the block initially begins to slide down on its own, the slope is probably too great! Once moving, the block should slide on its own with constant velocity. Record the angle.

TRIAL 2

Repeat the process listed in trial 1. Record the angle.

- ## <u>PART 2: Wood block sliding upward</u>

TRIAL 3 thru 7

APPARATUS SET-UP NOTE: Place your incline plane apparatus near the edge of the lab table such that your hanging weights can freely fall unobstructed below the table top surface.

Attach a string to your wood block and pass the string over the pulley at the top of the incline. Tie the other end of the string to your masses. You will be setting the incline at the different angles as listed in the data table and adding masses until the wood block slides upward at a constant velocity. Remember, you need to overcome static friction by giving the wood block a "starting" push. Record the masses needed to achieve a constant sliding upward velocity.

Calculate the following quantities and record them in your data table:

F_g Weight of wood block
F_{gy} Weight of wood block perpendicular to the plane
F_{gx} Weight of wood block parallel to the plane
F_N Normal force = F_{gy}
$F_{Applied}$ Force that is applied due to hanging weight
F_f Frictional force (always opposes direction of motion)
μ_k Coefficient of kinetic (sliding) friction

GRAPH:

Prepare a graph using your data for trials 3 thru 7: use the values for F_f and F_N. Plot the frictional force F_f as the ordinate (y axis) and the normal force F_N as the abscissa (x axis). Note the value of the slope.

DATA:

Mass of wood block: _______________ **kg**

Weight of wood block (F_g) ______________ **N**

Trial #	Incline Angle	Hanging Mass (kg)	F_{gx}	F_{gy}	F_N	$F_{Applied}$	F_f	μ_k
1								
2								
3	5 degrees							
4	15 degrees							
5	25 degrees							
6	35 degrees							
7	45 degrees							

Average coefficient of kinetic friction = [ ]

QUESTIONS:

1) The coefficient of kinetic friction should be the same for each trial. Explain why.

2) Why should the wood block be started with a slight push in each trial?

3) Describe the relationship your graph shows between the frictional force and the normal force. What is this relationship?

4) List and discuss all sources of error.

5) What effect has the moisture content of the sliding wood block in this lab? Explain. Offer an alternative procedure to control (or measure) the effects of this variable.

6) Given that your incline is painted wood and the sliding block is unpainted wood, present an argument that supports the “reasonability” of your calculated coefficient of kinetic friction; you must reference known coefficients from your text book to support your argument.