Student ID Number:

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3. FRICTION and FINDING FRICTION COEFFICIENT OF MOTION

Purpose of the Experiment: Finding friction coefficient and examining the effect of friction on motion

Theory

As seen in Figure-1, in response to the perpendicular force F_d pressing an object on the surface, the surface also affects the object in the opposite direction, with a reaction force N with the same magnitude. If a force F_p tries to move the object, the frictional force f_s, with a maximum value of $f_s^{max} = \mu N$, tries to oppose the motion. If $f_s > F_p$, the object does not move. The $\frac{F_s}{N} = \mu_s$ obtained by increasing F_p while the object is stationary is called the static friction coefficient, and the friction coefficient defined by $\frac{F_k}{N} = \mu_k$ during the motion is called the motion (kinetic) friction coefficient.

The force that accelerates an object is the total force acting on the object. Since the sum of the N and F_d forces in Figure-1 is zero, the total force will be the difference between F_p and f_s.

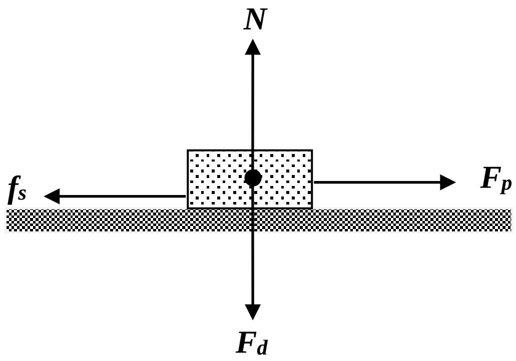


Figure-1

The static frictional force between two surfaces in contact with each other is in the opposite direction to the applied force and has a value of $f_s \leq \mu_s N$. Here μ_s is the coefficient of static friction and is dimensionless.

The kinetic friction force acting on a moving object always occurs in the opposite direction to the motion of the object and has the value $f_k = \mu_k N$. Here μ_k is the coefficient of static friction and is dimensionless.

In order to experimentally determine the μ_s coefficient, an object can be taken on an inclined plane as shown in the figure below. The forces acting on the object on the inclined plane are shown in Figure-2. The angle of inclination of the inclined plane is increased until the object reaches the threshold of motion. At the threshold of motion, the angle of inclination of the inclined plane is determined. Using this critical angle value, μ_s is found.

$$mg\sin\theta - f_s = 0; \qquad f_s^{max} = \mu_s N$$
$$mg\sin\theta - \mu_s N = 0$$
$$mg\sin\theta - \mu_s mg\cos\theta = 0$$
$$\mu_s = \tan\theta = \frac{h}{\ell}$$

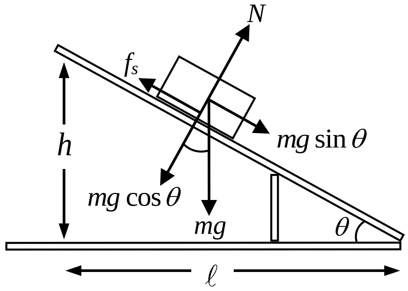


Figure-2

An object can also be taken on an inclined plane to experimentally determine the coefficient of kinetic friction μ_k (Figure-3). The object must be moved either with a constant speed or with an acceleration on the inclined plane. It is easier to move with acceleration. Therefore, the inclined plane is set to a value slightly above the critical angle value and the object is accelerated. In this movement, it is measured how long it takes the object to travel a certain distance. Using this, the acceleration is calculated and the kinetic friction coefficient μ_k is found by substituting it in the equation.

$$mg\sin\theta - f_k = ma; \qquad f_k = \mu_k N$$
$$mg\sin\theta - \mu_k N = ma$$
$$mg\sin\theta - \mu_k mg\cos\theta = ma$$
$$\mu_k = \frac{g\sin\theta - a}{g\cos\theta}$$

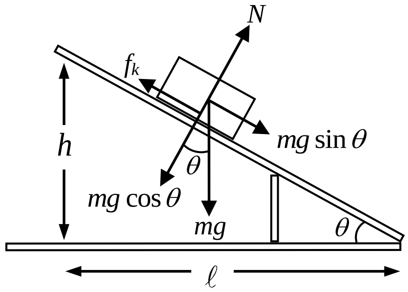


Figure-3

EXPERIMENT 1. Coefficient of Static Friction

Procedure

- Place the block on the inclined plane so that the cloth surface is on the slip plane. By increasing the θ angle gradually, determine the θ value when the block starts to move, write it in the table. Repeat the experiment three times.
- Calculate the static friction coefficient from the expression $\mu_s = tan\theta = \frac{h}{\ell}$ for each measurement, write it in the table.
- Determine average value of μ_s.

	1.	2.	3.
θ value			
h value			
ℓ value			
Calculated μ_s values			
Average μ_s			

Comment:

EXPERIMENT 2. Coefficient of Kinetic Friction

Procedure

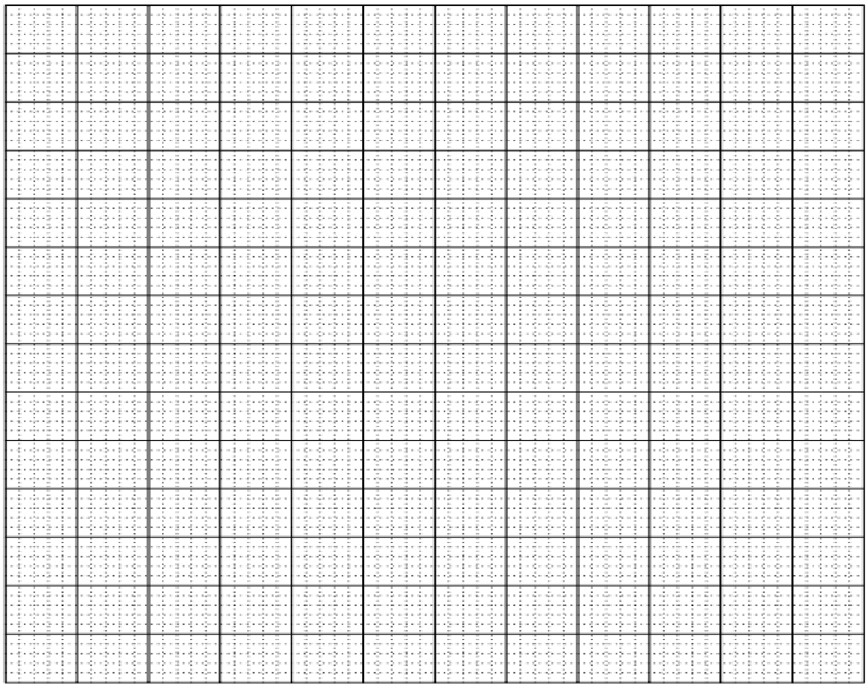
- Set the inclined plane to an angle value slightly above the block's motion threshold and record this angle value in the table.
- Release the block and measure how long it takes to get the distances shown in the table. Perform the experiment twice for each distance, write the measurements in the table.
- Calculate the average of the measured times.
- Calculate the squares of these average times. Draw a distance-time square graph using the time squares and distances. The slope of the line obtained from the graph $x-t^2$ will be;

$$\frac{\Delta x}{\Delta(t^2)}=\frac{1}{2}a$$

- Find the experimental value of acceleration a from the graph.
- Calculate the kinetic friction coefficient from the expression $\mu_k=\dfrac{g\sin\theta-a}{g\cos\theta}$ and write it in the table.

θ (°)	

x (cm)		40	50	60	70
t (s)	t_1				
	t_2				
Average t (s)					
t^2 (s^2)					
a (cm/s^2)					
μ_k					



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