# Student ID Number: Name Surname: Department:

### **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  $f_s$ .





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  $f_s \le \mu_s N$ . Here  $\mu_s$  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  $\mu_k$  is the coefficient of static friction and is dimensionless.

In order to experimentally determine the  $\mu_s$  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,  $\mu_s$  is found.



An object can also be taken on an inclined plane to experimentally determine the coefficient of kinetic friction  $\mu_k$  (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  $\mu_k$  is found by substituting it in the equation.



# **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  $\mu_s$ .

	1.	2.	3.	Comment:
$\theta$ value				
h value				
ℓ value				
Calculated $\mu_s$ values				
Average $\mu_s$				

## 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  $\mu_k = \frac{g \sin \theta a}{g \cos \theta}$  and write it in the table.

θ (°)	
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<i>x</i> (cm)		40	50	60	70
t (c)	$t_1$				
<i>i</i> (3)	$t_2$				
Average	<i>t</i> (s)				
1	$t^{2}$ (s <sup>2</sup> )				
a (	$(cm/s^2)$				
	$\mu_k$				

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