**Lab 5: Newton’s Second Law with Friction**

**Objective:** To measure the forces and acceleration to validate Newton’s Second Law.

# **Equipment**

* A track.
* Toy cart.
* Two Photo gates.
* A Hanging Mass
* A String
* Computer to connect the photo gates.
* Meter stick.

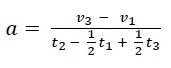
# **Procedure**

1. Prepare the timer by connecting the photo gates to the computer.
2. Prepare the track. Carefully set the track horizontal and attach the string to the cart and a hanger.
3. Weight the cart with the string and the hanging mass.
4. Place the cart in one extreme of the track and then drop the hanging mass and record

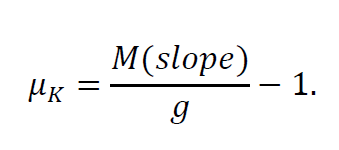
The hanging masses

T1: time for the tab on the cart to pass through the first photogate)   
T2: time between the start of t1 and the start of t3

T3: time for the tab on the cart to pass through the second photogate.  
Repeat 4 more times with the same hanging mass.

1. Calculate V1 and V3 with respect to the Length of Tab and T1 or T3 (i.e. V1= Length of Tab / T1 and V3 = Length of Tab / T3).
2. Calculate the acceleration for the runs with the formula
3. Take the average and standard deviation of the accelerations that you got.
4. Repeat steps 2 – 6 four more times, each time by changing the Hanging mass.
5. Create one (X, Y) Scatter graph with the average accelerations and height got from the lightweight cart and another for the heavy cart.
6. Add a trendline to the graphs and show its function.

Calculate Mk assuming that: (g = gravity and M = Total Mass).



1. Calculate Mk with the Y intercept where Mk = ( y-intercept ) / g

**Data**

**Results:**

Answer the following questions in the results section of your laboratory report.

• The uncertainty in the coefficient calculated using the slope is +-0.05. What was the coefficient of friction using the slope of the line, with uncertainty?

1. 0.365 (+-) 0.05

• The uncertainty in the coefficient calculated using the y-intercept is (+-)0.02. What was the coefficient of friction using the y-intercept, with uncertainty?

1. 0.296 (+-) 0.02

• Do your two values of the coefficient of friction match within uncertainty?

1. Yes

• There are two main types of error within a laboratory experiment, systematic error and random error. Systematic errors are instrumental or methodological mistakes causing the data to be skewed or lopsided. Random errors are caused by uncontrollable fluctuations of variables that change the experimental results slightly each time the experiment is run. Hypothetically, let us say that the coefficient of friction calculated using the slope of the line did not match the coefficient of friction calculated using the y-intercept within uncertainty. What type of error is the most likely culprit?

1. Systematic error.

**Conclusion :**

With this experiment, the measurement of acceleration of the masses was determined from the mass loads, and a value for the acceleration of gravity was calculated from time measurements. The results are in close agreement with the hypothesis that the acceleration of the object observed being directly proportional to the net force acting on the object and inversely proportional to the total mass of the object. Mk calculated with y-interception vs Mk calculated with slope were within the uncertainty.