

Lab 04 – Friction 2 and Kinematics

Introduction/Background

In this lab, we will use Newton's laws to find the acceleration of a block sliding down an inclined plane, and then use the kinematic equations to predict the time that it takes to slide a certain length. Consider a block on a plane drawn below. Newton's second law tells us that the acceleration, a , of the block down the plane (assuming that it is moving on the inclined plane) is

$$a = g(\sin \theta - \mu_k \cos \theta).$$

Here, θ is the inclination angle of the plane with respect to the horizontal, μ_k is the coefficient of kinetic friction, and g is the acceleration due to gravity.

If there is a constant acceleration, then the position of the object at any time can be given by the kinematic equations. The equation relating x-position and time (the x-kinematic equation) is

$$x(t) = x_0 + v_{x0}t + \frac{1}{2}a_x t^2.$$

Here, $x(t)$ is x-position at time t , x_0 is the initial x-position of the object, v_{x0} is the initial velocity in the x-direction of the object, and a_x is the acceleration in the x-direction of the object.

Description of Experiment

- 1) In this experiment what you will do is take a wide book or a board, and place the wooden block from the labpaq kit on top of the book or board (the plane), on one end. Gradually lift up one end of the plane, giving the block on it a little tap periodically, moving it slightly. At some angle the block will begin sliding down the plane after a tap and will continue sliding with a constant velocity. While holding the plane at this angle (prop it up with a few other books or something like that, just state in the report how you do this), measure the angle the plane makes with respect to horizontal, using the protractor in the kit. You can do this by putting the center of the flat side of the protractor at the corner of where the plane touches the table or floor (see Fig. 1). Repeat so you have 10 measurements of this angle. When the block moves with a constant speed down the plane, $a = 0$. Use your average angle to find the coefficient of kinetic friction between the block and the plane.

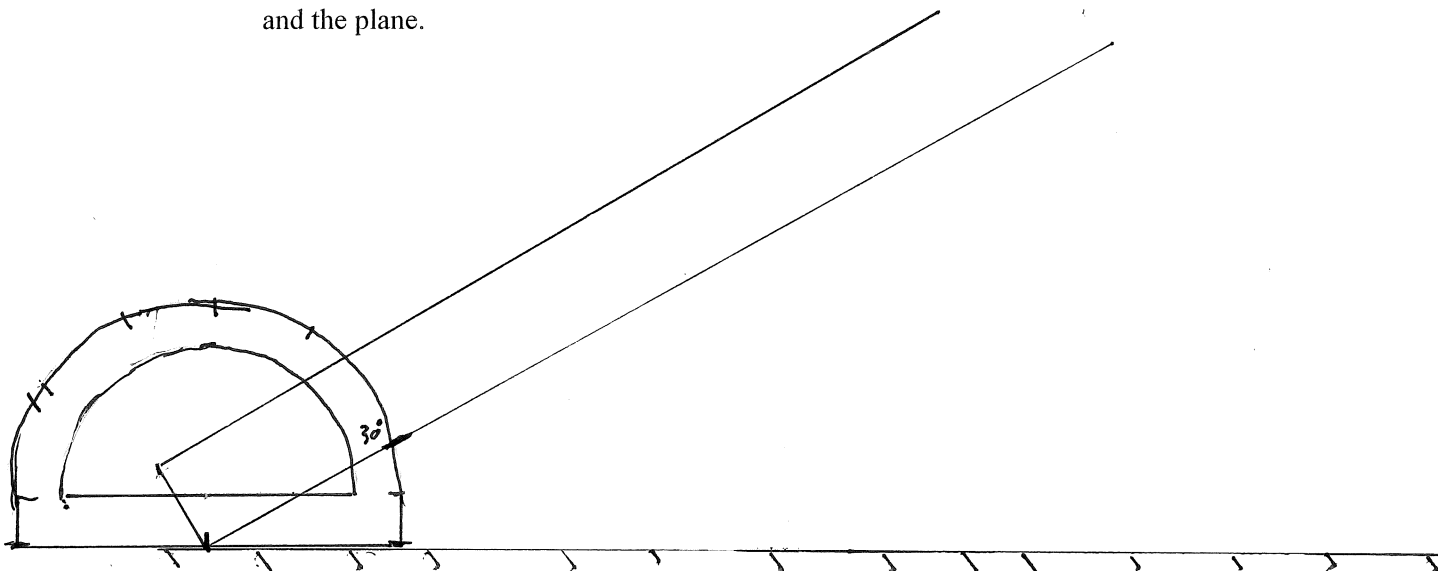


Fig: Using Protractor to measure Angle of board (30° with respect to floor in this example)

- 2) After you have the coefficient kinetic friction, increase the angle of the plane by 10 degrees from the angle in part 1. At this angle, the block should slide down the plane from rest without any tapping. If this is not the case, increase the angle further until it does, and then record the angle. Place the block at one end of the plane, and measure the distance the block has to slide to get to the other end of the plane. Predict the acceleration of the block down the plane, using Newton's second law, and then predict the time to it would take for the block to slide down the plane using the kinematic equation. Find an uncertainty in this predicted time by propagating the uncertainty in the length to slide, the coefficient of kinetic friction, and the angle. Let the block slide down the plane, and measure how long it takes using the stopwatch. Repeat until you have 5 sliding-times.

Special Instructions for Report

In your report, draw a free body diagram of a block on the inclined plane. Using a coordinate system that is tilted so that the x-direction is along the plane, and the y-direction points directly away from the plane, derive the equation for the acceleration down the plane.

Make sure you include your raw data for part 1 and 2.

For part 1, find the average inclination angle, and use the standard error as the uncertainty in this angle.

For part 2, report the predicted time to slide down the plane and the uncertainty in this predicted time.

Show your work on how you got this uncertainty in the predicted time. Also report your average measured time, and the uncertainty in this average measured time.

Question:

Are your predicted and measured times for part 2 consistent with each other (hint: use z' test)?