# Physics 123
# Experiment 2: Newton's Second Law

January 26, 2003

## 1 Motion on the Inclined Plane

In 1608, Galileo Galilei wanted to investigate the motion of falling objects. However, the objects fell too fast and it was extremely difficult to measure their velocities and accelerations. His solution was to roll the objects down an inclined plane, thereby controlling the effective forces and times. By the use of a frictionless air-track, we can make an even simpler system than Galileo's and use it to test Newton's second law of motion. An object slides down a frictionless inclined plane as in Figure 1.

The weight, $W$, of the glider can be resolved into horizontal and vertical components with respect to the surface of the incline. Since only motion along the incline is permitted, the component of the weight along the incline, $F_{net}$, is the effective force applied to the glider. According Newton's second law

$$a = \frac{F_{net}}{m} \tag{1}$$

It is this relation that you will be testing with your experiments. Acceleration in the above equation is difficult to measure directly, but it can be determined by measuring the instantaneous velocity experimentally and making use of the kinematic relation between acceleration and instantaneous velocity:

$$a = \frac{v^2 - v_o^2}{2x} \tag{2}$$

Where $x$ is the distance travelled, $v_o$ is the initial velocity and $v$ is the final velocity.

The "instantaneous" velocity of a glider is measured by timing how long it takes the glider, with a flag of known length, to pass through a photogate:

$$v = L/T \tag{3}$$

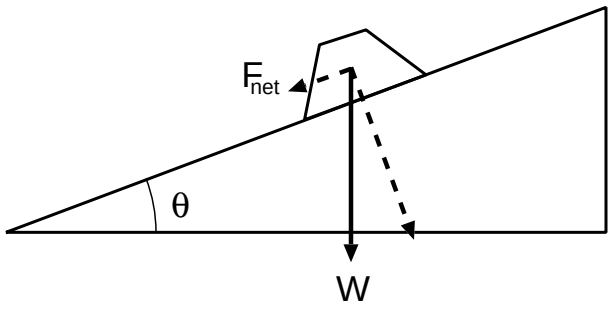


Figure 1: Motion on a frictionless inclined plane.

where $L$ is the length of the glider's flag and $T$ is the time to pass through photogate. The computer system you will be using will directly calculate the velocity of the glider as it passes through the photogate provided that you insert the correct flag length, $L$, when you first start the program.

## 2 Experimental Objectives

In the laboratory you have air track, glider, photogate, scale, wooden blocks, ruler, different weights that can be placed on the glider. The photogate is connected to a computer data acquisition system and velocity data can be collected using the "Science Workshop" software (see manual or ask your TA about using this software in your experiment).

- Devise an experimental procedure to test Newton's second law (Equation 1 above) assertion that the acceleration is proportional to the effective force applied to the glider. Take a thorough set of measurements which will permit you to calculate the acceleration as a function of the effective force applied. Make sure that you have consistent data and report error bars in your data analysis. Include a graph which summarizes your results.
- Devise an experimental procedure to prove to yourselves that it is impossible to use a simple inclined plane to test the assertion that the acceleration is inversely proportional to the mass. Why is this so? With a bit of additional analysis of Equation 1 you can find that it is independent of mass.
- By using other equipment available to you in the lab (pulleys, strings, hanger, masses and springs), devise a procedure that could verify the inverse proportionality of the acceleration and the mass. Think of how you could achieve a consistent (not necessarily constant) applied force, independent of the mass of the glider. You do not necessarily have to know the details of the force, just make sure it is the same for all experiments. Think of a good way to plot these data to show the inverse proportionality.

In order to minimize random errors, it is very important that each of your measurements to be performed several times. Show error bars on your graphs. Make sure that you discuss all possible sources of systematic error in your experiments. In particular, think about and discuss whether the photogate system is measuring the true instantaneous velocity.