Aerodynamics Forces on Frisbee

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(Dated: May 5, 2016)

The initial idea of the ultimate frisbee disc was first invented by Fred Morrison in 1938 when him and his wife were tossing around an empty cake pan. Over the years, Morrison developed several prototypes which eventually became the modern-day ultimate disc. Richard Feynman modeled the disc as a "wobbling plate" to describe the motion of the frisbee [6]. The purpose of this experiment wasn't to model the motion of the disc but describe and explain the forces on a frisbee with air drag.

I. INTRODUCTION

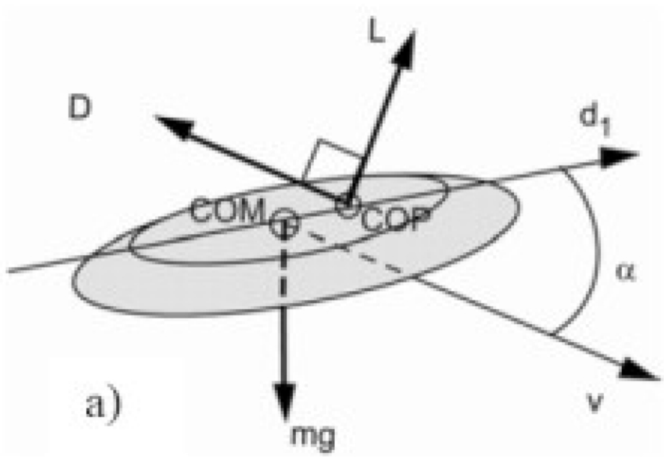

FIG. 1: This figure shows the setup procedure used during this experiment.

Richard Feynman once modeled the rotation and motion of a "wobbling disc" similar to an ultimate frisbee. He took moment of inertia, angular velocity, and angle of attack into account. This model was just to describe the motion. This experiment took a different approach and wanted to model the force on the frisbee changing the angle of attack therefore changing the surface area as the frisbee travels through the air shown by Fig. . To model the frisbee traveling through the air, a wind tunnel was built with a chamber able to insert a pivot arm attached to the frisbee. Instead a modern-day 175 gram frisbee, we used an mini-frisbee weighting approximately 28 grams.

II. SETUP

Fig. 2 shows the initial position of the system being tested. The initial trials began with the pivot arm being at 90 degrees with relation to the x-axis. As the experiment continued, the angle of the pivot arm was changed with respect to the x-axis called the attack angle. Therefore, the surface area of the frisbee was changed ultimately changing the force on the disc.

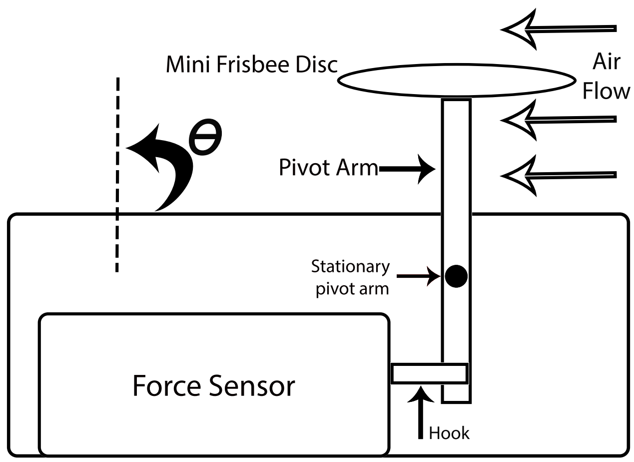

FIG. 2: This figure shows the setup procedure used during this experiment.

III. MODEL

Initially, the model relied on the rotation of the disc. Practicality though, there were problems with a spinning disc inside the test chamber. Enabling the spinning motion was not the problem, but measuring the force on the pivot arm while the disc was spinning was the problem. It was not practical in my initial setup so the only variables that were changed were the voltage powering the fan and the angle of attack. Then from Morrison's paper, his model was

$$F_{total} = F_{drag} + F_{lift}, \tag{1}$$

but this experiment did not have the proper equipment to measure to the Lift Force so we were left with only the Drag Force. Therefore my model came out to be

$$F_{drag} = -\frac{C_D \rho A v^2}{2}, \tag{2}$$

where ρ is the density of air which is constant for this experiment, C_D is a coefficient determined by the physical attributes of the frisbee, and v is the velocity of the frisbee. This follows the previous groups work that the model of the drag force should be close to a quadratic fit model.

IV. DATA

My first task was to collect data over the same object as the previous group. By doing this, it ensures that the equipment and model are up-to-date and works shown by Fig. 3. This is shown in the analysis section with the curve fit.

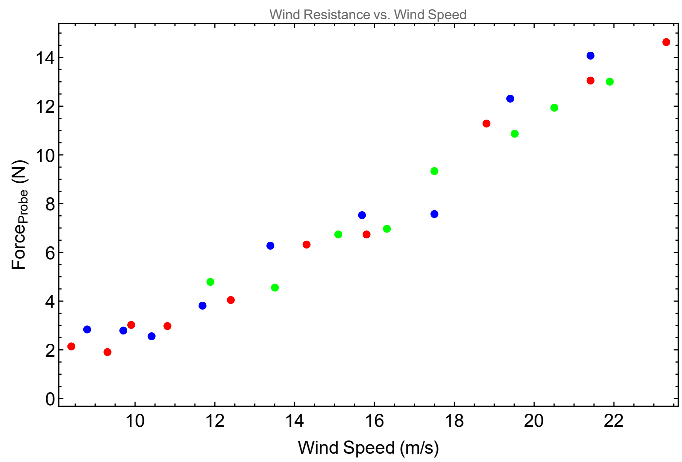

FIG. 3: This plot shows the raw data over three trials of measuring the force upon the racquetball.

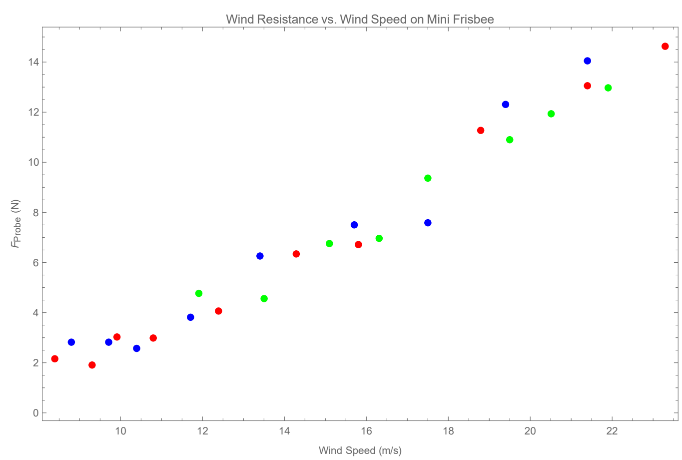

FIG. 4: This plot shows the raw data over three trials of measuring the force upon the mini frisbee.

Shown in Fig. 4, the data from the mini frisbee at 90 degrees was collected. During those trials, only the voltage was changing. This shows a similar relationship of the force on the mini frisbee as the racquetball. They both follow a parametric equation and this makes sense with such a small cross-sectional area of the mini frisbee when it is as 90 degrees.

V. ANALYSIS

Based off Fig. 6, we were able to establish a clear relationship between the force of the that agreed with the predicted model.

However, looking at Fig. 7, when the angle was varied, there was no clear relationship and the model fit did not agree with the data whatsoever.

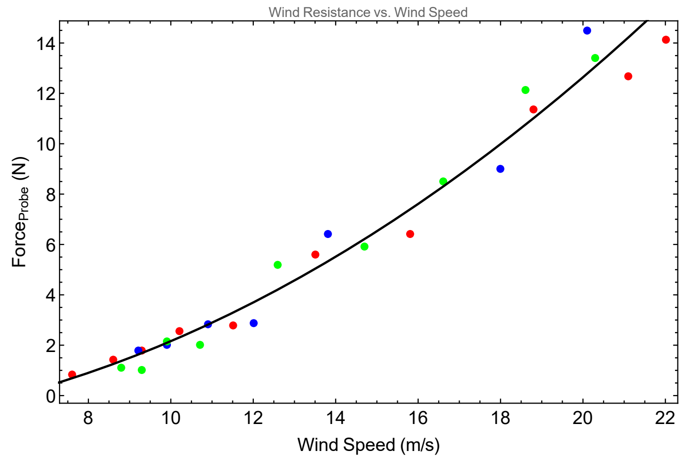

FIG. 5: This plot shows the raw data over three trials of measuring the force upon the racquetball.

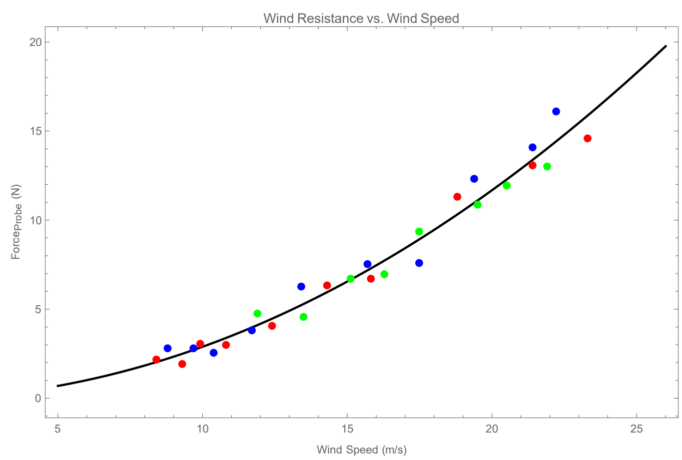

FIG. 6: This plot shows a model with the three data sets of measuring the force upon the mini frisbee.

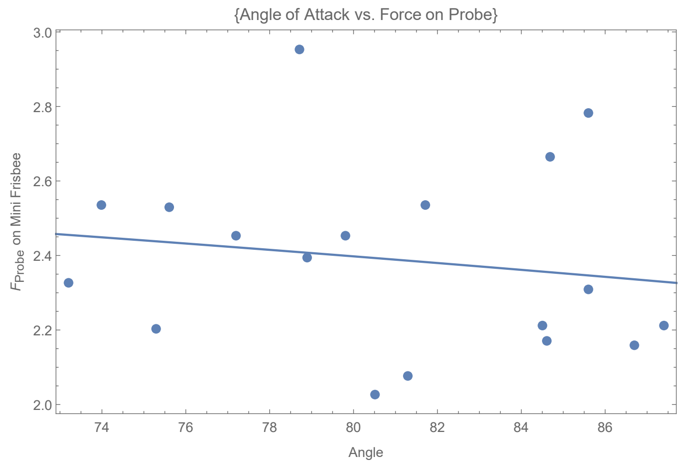

FIG. 7: This plot shows the raw data and model of measuring the drag force upon the frisbee as the angle of attack was varied.

VI. CONCLUSION

Based on Fig. 6, a clear relationship between the Drag Force and the wind speed is present but when the angle of attack of the frisbee (changing the cross sectional area of the mini frisbee) is changed, there appears to be no relationship whatsoever. This could be due to the setup of the mini frisbee yielding unreadable results. Further work should be done to include the lift portion of the proper model of the total force on a rotating disc.

ACKNOWLEDGMENTS

We acknowledge the help and support of the Wabash College Physics Department.

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