Determining the Exponent of the Drag Equation

Abstract

In this lab, we set out to determine whether the function determining drag was linear or quadratic. We chose to do this by comparing the terminal velocity of several sets of filters with their respective masses, and observing the resulting curve. We used sets of nested coffee filters, which had the same drag coefficient but variable mass (the number of filters in the stack). The data set produced a linear graph, indicating that drag coefficient of an object is determined by a linear function.

Theory

The purpose of this lab was to determine the exponent in the formula $F_d = -bv^x$. We decided to use coffee filters as masses because of their relatively low terminal velocities and their ability to stack into one another. Their low terminal velocities enabled us to collect our terminal velocity data within a low vertical distance. Their ability to stack into one another allowed us to essentially ignore the effects of drag. By stacking the filters, the shape of the different mass sets (1 filter, 2 stacked filters, 3 stacked filters, etc) would be the same, making the drag coefficient constant throughout our trials. By dropping the filter sets and recording their terminal velocities, we would be able to create a terminal velocity versus mass graph. Analyzing this graph would produce some sort of curve- either a linear one, or a quadratic one.

Equipment

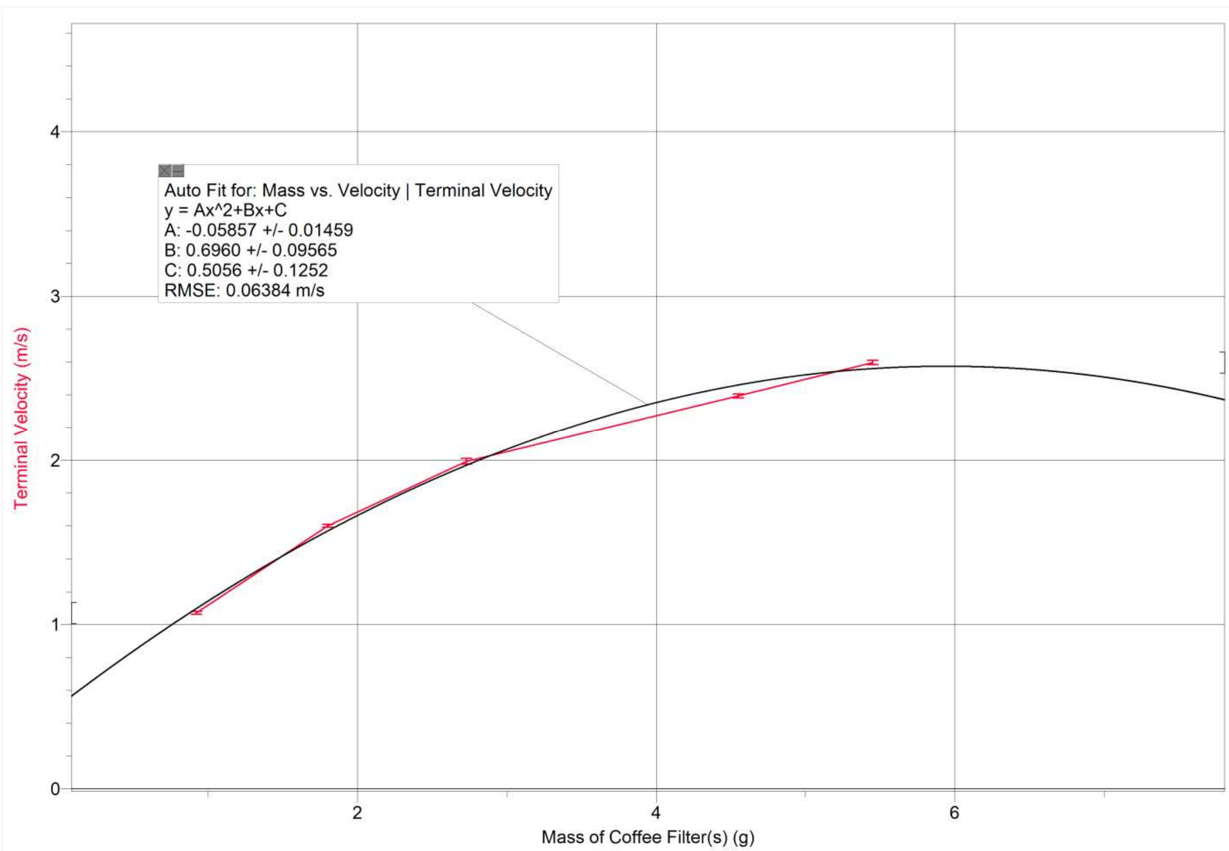
15 coffee filters
Duct tape
LabQuest
UMD
Scale
TI-84 Plus calculator

Procedure

1. We set up the coffee filters, making groups of 1 filter for the first test, two filters for the second, three for the third, four for the fouth and five for the fifth test.
2. We measured and recorded the mass of each of the coffee filters.
3. We set up the UMD taped to the ceiling pointing downward, with the cord taped out of the way.
4. We set up the LabQuest, with a data point collection rate of 15 samples per second, and a recording time of 5 seconds.
5. We dropped the first test at a time vertically from directly below the UMD as it recorded position and extrapolated velocity data.
6. We analyzed the UMD produced graph and recorded the terminal velocities of the objects.
7. We plotted the mass (independent variable) vs. the terminal velocity (dependent variable). We examined the data, confirming that the sample followed a quadratic trend.

Data/Analysis:

	Mass of Filter Set	Average Terminal Velocity	Error bar
Set 1	0.92	1.07	0.00816
Set 2	1.8	1.6	0.00816
Set 3	2.73	1.993	0.01700
Set 4	4.55	2.993	0.01247
Set5	5.45	2.597	0.01247



Conclusion

The force of drag is $F_d = -bv$, where b is a constant of proportionality.The purpose of the lab was to determine whether the function for determining drag was linear or quadratic (based on v or v^2). If the function were quadratic, it would be equal to $-bv^2$. Let's say the function is linear; for a falling object, $F_{NET} = mg - bv$. So the terminal velocity should be $v = mg/b$, as opposed to $v = (mg/b)^{1/2}$. Since g and b are constants, the only variable of interest is m. Plotting m versus the terminal velocity for the five sets of trials for various masses results in a curved graph, and the info-box on the graph shows the fit line is of the form $Ax^2 + bx + c$.