

# The Power of Velocity in the Force Law of Air Resistance

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## **Abstract:**

The goal of this lab was to determine the power of velocity in the force law for air resistance. We calculated the terminal velocity (the velocity at which the force of gravity and the force of drag yield a Net Force of  $0 \text{ m/s}^2$ , meaning that the object does not accelerate) of four different masses by using the UMD and LabQuest. With the specific masses and terminal velocities, we then plotted points and were able to perform a linear regression to find the best fitting line:  $y = .358M + .708$ . Since the relation between the mass and the terminal velocity of the trails created a line on a Mass vs. Terminal Velocity graph, the power of the velocity must be to the power of one.

## **Theory:**

In order to determine the power, we needed to measure certain things in the lab while running the tests. At terminal velocity,  $V_t = Mg/b$ , and  $F_{\text{Net}} = F_g - F_d$ , therefore  $Mg - bv_x = ma$ . We measured the terminal velocity of the coffee filter using the UMD, and the mass of the coffee filter plus the weight within it. The  $Mg$  remains constant, as does  $b$ , so as  $m$  changes we could compare that to changes in  $v_x$  (knowing  $v$ , we can solve for  $x$ ). Using the mass and the terminal velocity, we could graph them and fit regression curves to them.

## **Equipment:**

UMD  
LabQuest  
Coffee Filters  
Objects of miniscule (but varying) mass  
Textbooks  
Tape  
Pole stand and cross piece

## **Procedure:**

1. We collected coffee filters and recorded their masses, along with other objects, which we could put into the filters to vary the total mass.
2. We set up the stand, cross piece, and cross bar on a table with the cross piece hung over the edge of the table at a height that allowed the filter to reach its terminal velocity while falling (text books were placed on the base of the stand for security.) (see diagram on last page)
3. We set up a filter of known mass under the UMD (Ultrasonic Motion Detector) and a LabQuest, which were both placed at the top of the stand, and collected velocity data as the filter fell.
4. We repeated the previous step three times for each varied mass (a total of 4 masses) and recorded the terminal velocities that the falling filters reached.

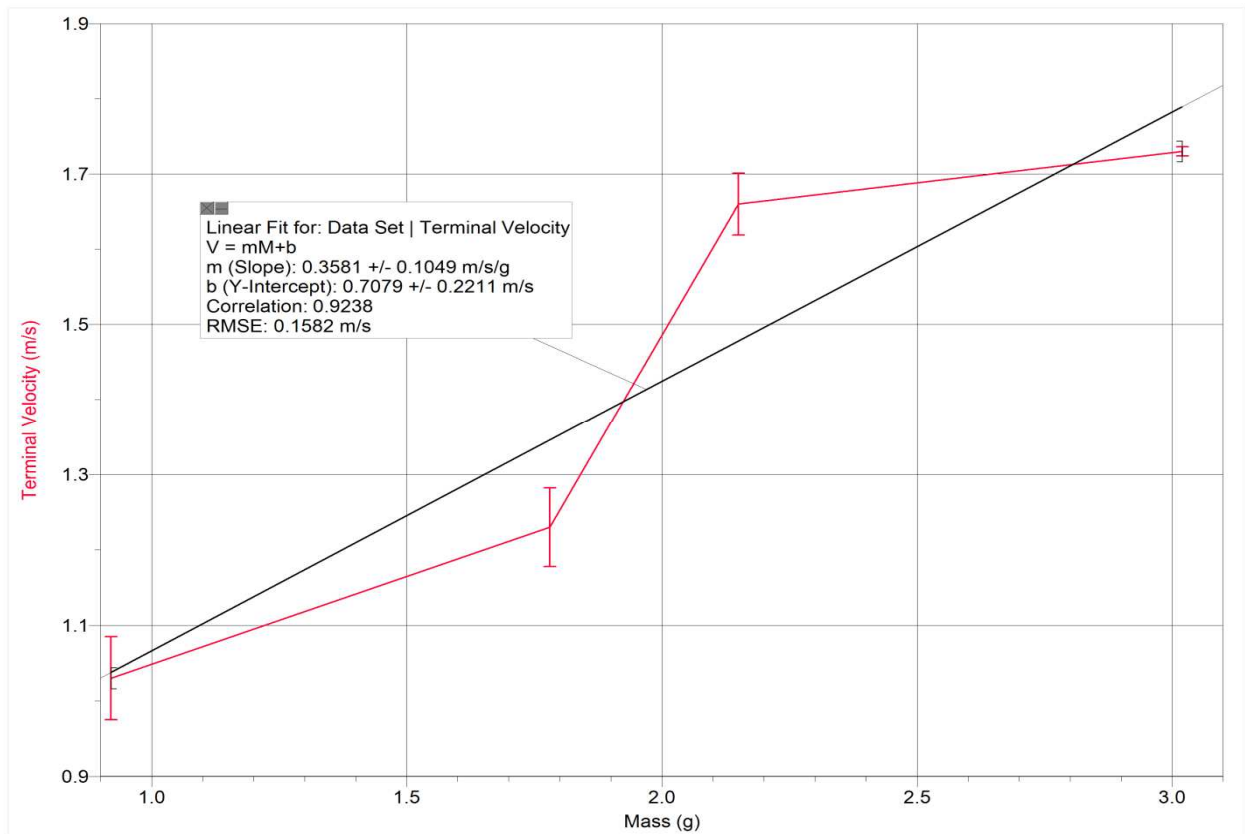
47 5. We entered the data into Logger Pro and fit a regression line to it.

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50 From the velocity graphs created by the LabQuest, we found the terminal velocity. To check that  
51 the velocity reached terminal velocity, we looked at a Velocity versus Time graph to see if it  
52 approached a horizontal asymptote. The terminal velocity is the value of the asymptote.  
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Mass (g)	Run1 $V_t$ (m/s)	Run2 $V_t$ (m/s)	Run3 $V_t$ (m/s)
0.92 g	0.97	1.07	1.06
1.78 g	1.29	1.20	1.20
2.15 g	1.71	1.65	1.63
3.02 g	1.73	1.72	1.73

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56 **Analysis:**  
57 Using the data above, we calculated the mean  $V_t$  for each mass and the standard deviation  
58 associated with that mean. We then graphed the points with their error bars in Logger Pro. With  
59 these points plotted we fit a linear regression ( $y=.358M+.708$ ). This regression is close to the  
60 data, and shows that  $m$  (Mass) versus  $V_t$  (Terminal velocity) is close to linear and therefore  
61 related by a power of 1.  
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Mass (g)	Mean $V_t$ (m/s)	Standard Deviation
0.92 g	1.03	.055
1.78 g	1.23	.052
2.15 g	1.66	.041
3.02 g	1.73	.006

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67 (Due to issues combining the graph from Logger Pro and this report from Microsoft Word, the  
68 graph is attached as a separate file)

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70 **Conclusion:**

71 By observing the several drops of the coffee filter that varied in mass, we were able to reach a  
72 conclusion about the power of velocity in the force law. When we graphed mass versus time on a  
73 Cartesian plane, we found that we were able to find a best fitting curve using linear regression.  
74 Because we were able to perform such a regression, the power of velocity is (1), because the  
75 graph is linear. The linear regression was not very well fit to the data, so the conclusion reached  
76 has possibility for error.

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