Air Resistance and Terminal Velocity

AP Physics C – Mechanics

Objective: I can determine the relation of velocity on resistive forces for a falling coffee filter by describing the velocity, acceleration, and position for falling coffee filters in relation to time.

For today's lab, you will be doing an experiment and analyzing data from a classic air resistance lab: determining the type of resistive forces that coffee filters experience (force related to velocity or velocity squared)!

Pre-lab Questions

1. Why are coffee filters perhaps ideal for studying air resistance? List properties of them that may be ideal.

They have a large surface area to interact with the air molecules and they have a low mass.

2. How should the number of coffee filters stacked together relate to the total mass of the stack?

This relationship is linear because each coffee filter should have the same mass.

3. Derive expressions for the terminal velocities of two objects: one under the influence of a linear drag force and the other under the influence of a quadratic drag force. Assume both objects are falling from rest.

Terminal velocity occurs when $a = 0$ therefore $F_{net} = 0$. This means drag must equal the gravitational force.

$$kv^2 = mg$$
$$v = \sqrt{\frac{mg}{k}}$$

$$bv = mg$$
$$v = \frac{mg}{b}$$

Materials

- Coffee filters
- Motion detectors
- PASCO Capstone
- Other materials as needed

Procedure

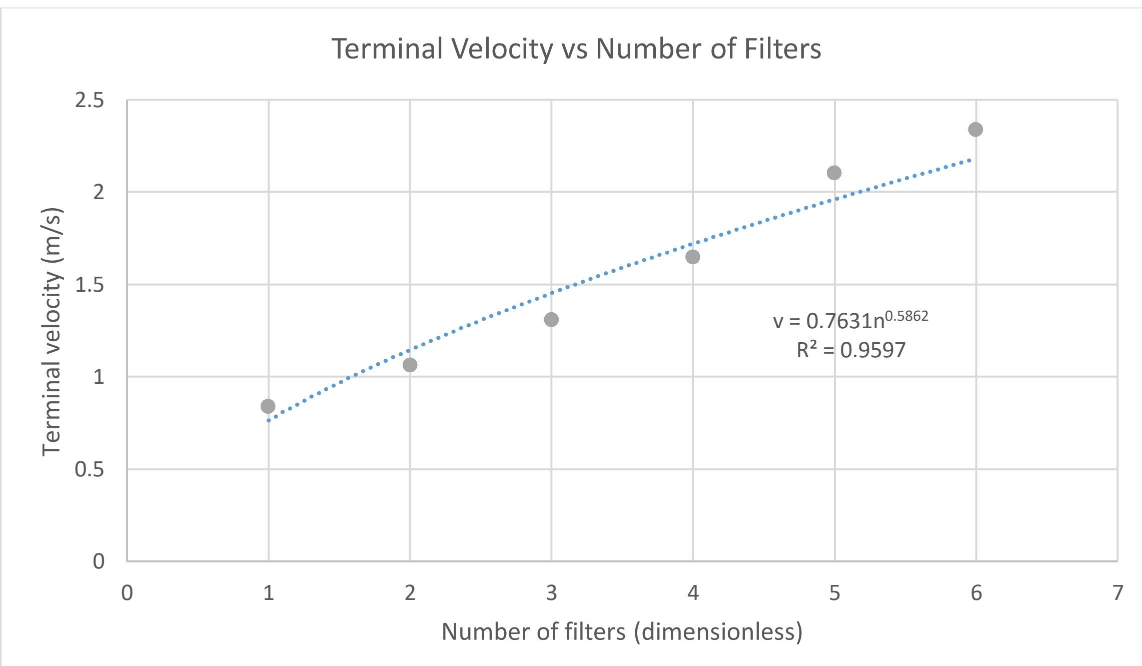
1. Connect your PASCO Capstone software to the interface and motion sensor.

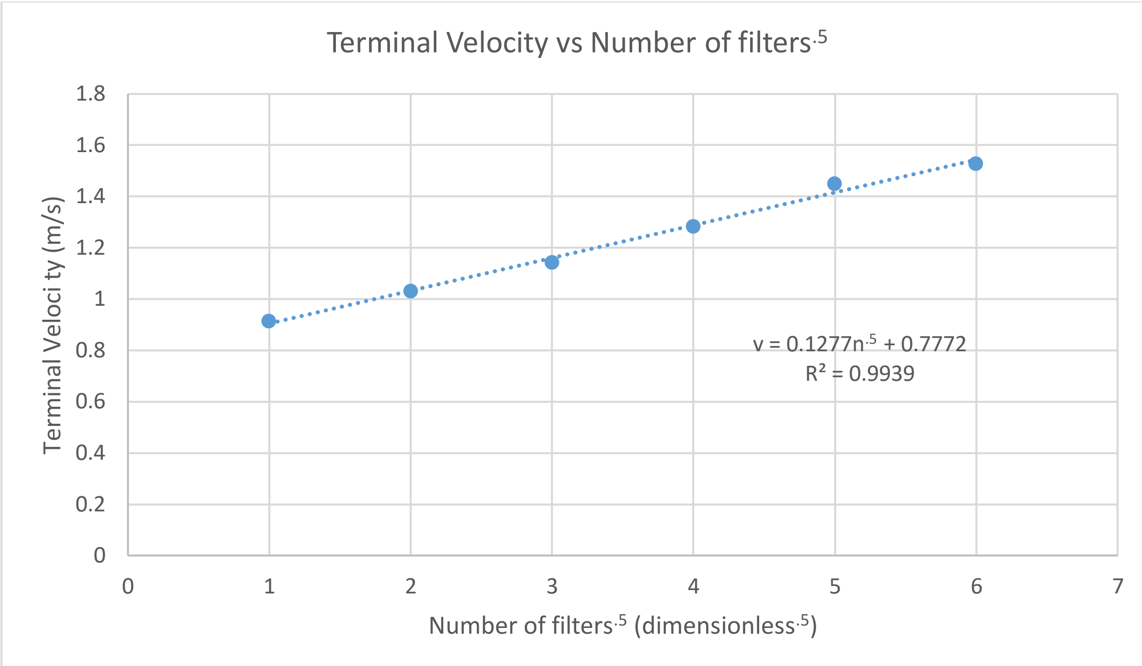
2. Display a Position/time graph and click “record” on Capstone .
3. Stack 6 coffee filters together and drop them from rest above the motion sensor (which should be on the ground with the speaker facing up).
4. Stop recording data.
5. Determine the terminal velocity of the stack using your position v. time graph and taking the slope when the graph appears linear (close to the end of the falling).
6. Record your data in the data table.
7. Remove one coffee filter from the top of the stack and repeat steps 2-6 until you have no more filters left.

Data

Number of filters N (dimensionless)	Terminal velocity v_{term} (m/s)
1	-0.837
2	-1.059
3	-1.307
4	-1.644
5	-2.100
6	-2.336

Results and Discussion





Describe the relation between terminal velocity and number of coffee filters using your graphs above. How does the motion of the object under influence of air resistance compare to the motion in a vacuum? Is air resistance significant in a laboratory setting? Look up the terminal velocity for other common items and compare to your items. Describe sources of error and how to minimize them.

Terminal velocity increases the more filters are added. The velocity of the motion in a vacuum will be the same no matter how many filters are added as air resistance will have no effects. Air resistance is significant in a laboratory setting as air is present in the laboratory. The terminal velocity of a pencil is around 15 m/s, much faster than the coffee filter. The flutter of the coffee filters contributed a great amount of error to the experiment, which could be minimalized in a controlled environment with minimal air currents caused by other moving people.