Union College **Winter 2022**

Physics 120 Lab 3: The Drag Force due to Air Resistance

The Experiment:

Time the fall of coffee filters to determine the terminal velocity and force of air resistance for 4 different size packets. Note: the coffee filters should be handled carefully to avoid changing their cross-sectional area. To make the groups of filters, page through an edge gently.

From a free-body diagram, when the filters reach terminal velocity, determine an expression for the drag force on the filters. You will need to make measurements to get values for the drag force.

Standing on the table (or on a set of stairs) drop the filters from as high as you can. Time the filter's fall over a distance of $\Delta y = 2m$ or higher if possible. Determine the terminal velocity of the filters.

Analysis:

The goal is to determine, empirically, how the force of air resistance depends on the velocity of the falling object. Since most laws of physics involve power laws, we start with the assumption that

$$F_{drag} = Kv^p,$$

where p is the "power" index of the velocity in the drag force of air resistance equation, and K is a set of constants. The goal in this lab is to determine the value of p and the drag coefficient for a coffee filter from K. Taking the log of both sides of the equation above, and applying some rules of logarithms we get:

$$\log F_{drag} = \log K + p \log v$$

Note that this is the equation of a straight line: $y = mx + b$, where the slope (m) equals the power index (p) of the velocity and the y-intercept is related to K. So, if the force of air resistance should indeed be a power-law, the plot of log(F) vs. log(v) should be a straight line AND the slope of that straight line equals the power index of velocity.

Do the data fit a straight line? If so, then your first conclusion is that the relationship between F_{drag} and v is indeed a power law. Then, fit a "linear" trendline (select "show equation on chart"), read the slope from the equation and set that equal to the p.

Do the following in Excel to perform a regression analysis to obtain *the uncertainty* in the slope:

- -Under the "data" menu, select "data analysis."
- -Select the columns of data for the x axis and y axis data.
- -In the new chart that appears, the slope, y-intercept, and their uncertainties are the four numbers in the lower left corner.

Determine the drag coefficient (C) of your coffee filters from the y-intercept of your graph. You will have to determine K from the y-intercept and recall from class or from your textbook that $K = \frac{1}{2}CA\rho_{air}$. To do this you will need to measure the cross-sectional area (A) of the filter(s) and take the density of air to be $\rho_{air} = 1.3\frac{kg}{m^3}$.