Name: ________________________ Date: ____________ Partners: _______________________

Preliminary questions

1. Hold a single coffee filter in your hand. Release it and watch it fall to the ground. Next, nest two filters and release them. Did two filters fall faster, slower, or at the same rate as one filter?

   What kind of mathematical relationship do you predict will exist between the velocity of fall and the number of filters?

2. If there were no air resistance, how would the rate of fall of a coffee filter compare to the rate of fall of a baseball?

3. Sketch your prediction of a graph of the velocity *vs*. time for one falling coffee filter.

4. When the filter reaches terminal velocity, what is the net force acting upon it?

Data Table

Number of filters	Terminal Velocity v_T (m/s)	(Terminal Velocity)^2 v_T^2 (m^2/s^2)
1		
2		
3		
4		
5		

Analysis

1. To help choose between the two models for the drag force, plot terminal velocity v_T *vs.* number of filters (mass). On a separate graph, plot v_T^2 *vs.* number of filters. Use your calculator, Excel, or graph paper. Scale each axis from the origin (0,0).

2. During terminal velocity the drag force is equal to the weight (mg) of the filter. If the drag force is proportional to velocity, then $v_T \propto m$. Or, if the drag force is proportional to the square of velocity, then $v_T^2 \propto m$. From your graphs, which proportionality is consistent with your data; that is, which graph is closer to a straight line that *goes through the origin*?

3. From the choice of proportionalities in the previous step, which of the drag force relationships ($-bv$ or $-cv^2$) appears to model the real data better? Notice that you are choosing between two different descriptions of air resistance—one or both may not correspond to what you observed.

4. How does the time of fall relate to the weight (mg) of the coffee filters (drag force)? If one filter falls in time, t, how long would it take four filters to fall, assuming the filters are always moving at terminal velocity?

Extensions

1. Make a small parachute and use the Motion Detector to analyze the air resistance and terminal velocity as the weight suspended from the chute increases.

2. Draw a free body diagram of a falling coffee filter. There are only two forces acting on the filter. Once the terminal velocity v_T has been reached, the acceleration is zero, so the net force, $\Sigma F = ma = 0$, must also be zero

$$\sum F = -mg + bv_T = 0 \qquad \text{or} \qquad \sum F = -mg + cv_T^2 = 0$$

depending on which drag force model you use. Given this, sketch plots for the terminal velocity (y axis) as a function of filter weight for each model (x axis). (Hint: Solve for v_T first.)