Terminal Velocity

You may work with a partner during this activity. Your instructor will provide you with the coffee filters, which have a nut attached to the bottom for stability. You will need a stop watch.

1. Determine the mass of coffee filter plus nut in kilograms: _____

2. Radius of coffee filter in centimeters: _____
   Estimate the surface area, in square meters, of the bottom circular part of the coffee filter: _____

3. Determine the height, in meters, from which we will drop the coffee filter: _____

4. Drop the coffee filter, nut side down, and time, in seconds, how long it takes to land: _____

5. The equation for terminal velocity is derived from $\sum F_{y\,net} = \frac{1}{2}\rho v^2 A C_d - mg$, where $\rho =$ air density, A = area perpendicular to the direction of motion, $C_d =$ dimensionless drag coefficient, based on the shape of the object. Our coffee filter is approximately the shape of a hemisphere, so its drag coefficient C_d is about 0.42 (Wikipedia, http://en.wikipedia.org/wiki/Terminal_velocity and http://en.wikipedia.org/wiki/Drag_coefficient). The density of air, ρ, is approximately 1.2041 kg/m^3 (Wikipedia, http://en.wikipedia.org/wiki/ Air_density). $v_t = \sqrt{\frac{2mg}{\rho A C_d}}$. Calculate the coffee filter's terminal velocity v_t.

6. Calculate the coffee filter's acceleration, *a*, assuming that it was constant (its not, but we'll use it as an estimate), and assuming that its terminal velocity is equal to its final velocity. Also assume that the nut is part of the coffee filter. Hint: $v_t = v_0 + at$, what was the coffee filter's initial velocity?

7. How does the calculated acceleration compare with *g*? If you calculated a value greater than 9.81 m/s^2 check your calculations or repeat this activity. Why should the acceleration of the coffee filter be less than 9.81 m/s^2?

8. If the coffee filter had a greater surface area (assume that its mass did not change), would this affect the terminal velocity? If so, how?

9. If the coffee filter had a greater mass (assume that its surface area did not change), would this affect the terminal velocity? If so, how?

10. If there had been no air resistance, wind, etc., how long would it have taken the coffee filter plus nut to reach the ground?