Modeling a Falling Column of Water – Class Handout

You will be collecting data to determine if there is a relationship between the height of a falling column of water and the rate at which it falls. Be sure that you have the prepared apparatus, a stopwatch, and a device to record videos.

Be sure that the soda bottle is on top of the stand with the bore hole aimed toward the receiving container. Place a stopwatch next to the apparatus. Then place a video camera (or cell phone in video mode) in a location where both the stopwatch and ruler on the bottle are in clear view. Have your instructor check that your setup is correct. When everything is in place, start the video, start the stopwatch, and tear away the tape covering the bore hole to let the water flow. Stop recording when the water stops flowing.

1. Once you have created the video, play it back, stopping when the stopwatch reaches evenly spaced time intervals. At those times, record data on the time and height of the water in the first two columns of the following table.

Time (t)	Height $h(t)$	$\Delta h(t)$	$(h(t))^2$	$(h(t))^{1/2}$

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2. Plot your data as $h(t)$ vs. time.
3. Fill in the rest of the table.
4. Use your data to find which of the following possible models best fits your data: $h'(t) = -k_1 h(t)$, $h'(t) = -k_2(h(t))^2$, $h'(t) = -k_3(h(t))^{1/2}$.
5. Find the constant, k_i, for the best fit model you just found.
6. Using your best fit model and associated constant, solve the differential equation for $h(t)$.
7. Plot your solution, $h(t)$, vs. time on the same axes as the plot you created above in Problem 2. How close are these plots? Is your model accurate? Is your model reasonable?
8. Research Torricelli's law. How does this relate to this problem?
9. Consider changing the physical configuration, such as changing the cylinder diameter, borehole diameter, water column height, etc. How would this change your mathematical model? How would this change the water flow in the experiment?