The Draining Bottle

Goal: To discover a relationship between the height of water in a bottle and the rate at which the height of the water changes as the bottle is drained through a hole in the bottom. Think of water draining from a bathtub.

Equipment

- Clear two-liter soda bottle
- Nail
- Tape
- Ruler
- Watch with second hand
- Basins or bags to catch draining water (or go outside)

Procedure

- Punch a hole in the bottle with the nail about 5 centimeters from the bottom of the clear two-liter soda bottle.
- Tape the ruler vertically to the side of the bottle so that the 0 centimeter mark is aligned with the hole punched in the bottle.
- First person puts finger over the hole and fills bottle with water to a height of about 15 centimeters
- First person calls out as finger is removed from hole and calls out height of the water in whole centimeters as the water level passes that height
- Second person calls out elapsed time each time the level passes a height
- Third person records results in the table.

Elapsed Time T	Height of H_2O h	Δh	Δt	$\Delta h/\Delta t$

The rate at which the height is changing is the change in height, Δh, divided by the change in time, Δt.

Any curve we fit to the data should have the property that when h is 0, $\Delta h/\Delta t$ is also 0 (convince yourself by thinking about the water draining from the bottle). In particular, if we fit a line, its equation will be

$$\Delta h/\Delta t = m * h;$$

i.e., the intercept is 0. This means when sketching a line on a graph, one edge of the ruler is on (0,0). (If using a graphing calculator or a spreadsheet consult the reference manual to determine how to set the intercept to 0.)

Fit a line to the data. (A straight line with intercept 0 does not fit the data very well.)

A little research on the Web or a careful look at the data itself might suggest a power function; i.e.

$$\Delta h/\Delta t = m * h^p$$

Use Excel or your graphing calculator to fit this curve. Note the values of m and p

<u>Reflect on Preconceptions.</u>

Where have we confirmed our conceptions? Modified our conceptions?

Sample Data for the Draining Bottle

Hole size – approximately 2.5 mm

What is the relationship between the height of the water and the rate at which the height is changing (decreasing)?

Time (t) (sec)	Height (h) (cm)	Avg. Rate of Decrease in h w.r.t t (cm/sec)	Square Root of Height	Ratio of Rate to Sq Root	Model Value (cm/sec)
0	15		3.87		
14	14	0.07	3.74	0.019	0.06
32	13	0.06	3.61	0.015	0.05
51	12	0.05	3.46	0.015	0.05
72	11	0.05	3.32	0.014	0.05
94	10	0.05	3.16	0.014	0.05
117	9	0.04	3.00	0.014	0.05
141	8	0.04	2.83	0.015	0.04
166	7	0.04	2.65	0.015	0.04
196	6	0.03	2.45	0.014	0.04
229	5	0.03	2.24	0.014	0.03
262	4	0.03	2.00	0.015	0.03
300	3	0.03	1.73	0.015	0.03
352	2	0.02	1.41	0.014	0.02
418	1	0.02	1.00	0.015	0.02

Best guess: 0.015 $r = 0.015(\sqrt{h})$