Raining on Tiny Town

Overview:
Flooding occurs when a large amount of water falls on an area in a small amount of time. Scientists and engineers need to quantify *how much* water falls in an area both to study where it goes and to make plans for moving water in ways that prevent flood damage.

In this activity, you will create a physical model of rainfall that accumulates in a location using a spray bottle and a catch basin. You will gather data from the model in much the same way that actual rainfall data is gathered, and use this data to make calculations and estimations of water quantities.

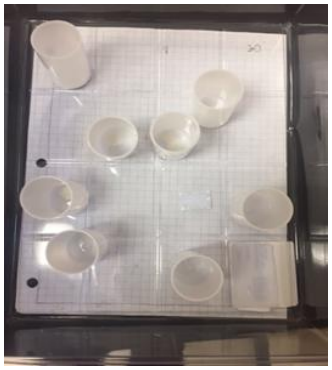
Materials and Resources:

Your research group should have the following:

- Data sheet or spreadsheet
- Flat clear plastic tub or basin, at least 3" deep and approximately 8.5 x 11 inches
- 8-10 empty film canisters or similar small cylinders with flat bottoms
- Clay, glue dots or other material to help anchor canisters to bottom of basin
- Spray bottle with mist option and a measured fill line (e.g. 500 mL)
- Small graduated cylinder, .1 mL gradations
- Larger graduate cylinder, 1 mL gradations
- Funnel
- Towels
- Small ruler or measuring tape (cm)
- Graph paper

Procedure:

1. Record your name and date on the Data Sheet
2. Set up rain gauges in "Tiny Town"
   a. Measure and record the length and width dimensions of the basin. Note that most basins will typically be a bit wider at the top, but that this wider dimension is the appropriate one to measure. (Can you see why?)
   b. Measure and record (on the data sheet) the diameter of each rain gauge, which may be the same if your gauges are a consistent size. Calculate the area of each rain gauge in square cm (these values should be the same for all your gauges).



   c. Using a sheet of graph paper and a PENCIL, draw an x,y axis on the paper, then "map" the pattern of your rain gauges on a sheet of graph paper and record a number label for each gauge (#s 1-10).
   d. Establish a Cartesian coordinate system using the sides of the basin as the reference axes. Using the cm ruler, measure "over" from the left side and then "away" from the

near side and record these two coordinates for each rain gauge (measure to the center of the gauge) on your data sheet, being sure to correspond the coordinates with the gauge label.

e. Slide the graph paper underneath the basin. If the basin is the same size or smaller than the graph paper, place a protective cover (like a transparency sheet) over the graph paper to keep it from getting wet. Distribute the 10 film canisters as "rain gauges" by placing them open-side-up inside the flat plastic basin (see photo on right), one for each location on your graph. Secure the canisters to the bottom of the bin using clay or glue dots.

3. Simulate the "Tiny Town" storm
   a. Fill the spray bottle with a measured amount of water (at least 500 mL). Record this Initial Volume on the datasheet. Set the spray nozzle to a strong 'mist' setting so that squeezing the trigger creates a mist of fine droplets and not a strong, directed squirt.
   b. Use the spray bottle trigger to create a mist that falls vertically downward into the basin. The goal is to ensure that the majority of sprayed water lands IN the basin and that some of it lands in the rain gauges without being directly targeted at the gauges. **Repeated sprays from a consistent location and angle are best**. Consider how you might best simulate accumulation from a natural rainstorm, but on a very small scale.
   c. Spray until at least 500mL of water has been emptied from the spray bottle. Note that larger amounts of water will take longer to spray, but will lead to easier measurements and more interesting data patterns. **STOP** before any of the rain gauges overflow. You will also want to avoid knocking over any rain gauges.
   d. Measure and record the amount of water remaining in the spray bottle when the storm simulation is complete. Record this End Volume on the datasheet. Subtract the End Volume from the Initial Volume and record this Estimated Total Rainfall.

4. Measure rainfall
   a. Detach a rain gauge from the bottom of the basin, being careful to retain the water accumulated inside. Tap it lightly inside the basin so that water on the outside of the gauge falls back into the basin.
   b. Measure the depth of the water inside the container as precisely as possible. Record this value on your data sheet in the row corresponding to the gauge number.
   c. Use the funnel to transfer the gauge water to the small graduated cylinder and measure and record the volume of the water as precisely as possible.
   d. Repeat for each of the other 9 gauges. **DO NOT POUR WATER FROM THE GAUGES BACK INTO THE BASIN.**
   e. Pour the water remaining in the basin through a large funnel and measure using the larger graduated cylinder. (Note that you may need to take multiple measurements). Record this volume of water.

Raining in Tiny Town
Calculations and Discussion

NAME:_____ **DATE:** _____

1. Calculate the <u>total</u> volume of water that accumulated in the basin. Show your calculations:

V_{tot}=_____

2. What percentage of water that fell actually ended up in the basin? Show your calculations:

3. Why is this percentage less than 100%?

4. Take the volume that fell on the basin (V_{tot}, from above) and divide it by the Area of the basin, which you should be able to calculate from the measured dimensions. Show your calculation:

5. What is this value that you just calculated? What does it represent? (Hint: include your <u>units</u> in the division and if you cancel them correctly, it will indicate what type of quantity the value represents)

Note that if you were measuring rainfall in a real system, you would likely only have information from the rain gauges and would not be able to measure the remaining water, like you did when you poured it from the basin. Now see if you can estimate the <u>total</u> volume of water that accumulated in the basin *using only the measurements from the rain gauges.*

6. Select a rain gauge. Note that we measured both the depth and the volume of the water in each gauge, *but we did not need to measure both*. Use the depth of water from one gauge sample to calculate the volume of that sample. Show your calculation. How well did the calculated volume compare to the measured volume?

7. Show a calculation that uses <u>all</u> of the gauge depths, but only the gauge depths, to estimate the volume for the entire basin.

8. Recalculate the volume of the entire basin, but use only the data for 5 of your 10 gauges. Show your calculations. Do you think this is a better or worse estimate of the total volume? Why?

9. How many gauges do you think would be 'enough' to get an accurate measure of rainfall volume in the Tiny Town basin? Why?

Vocabulary (define in your own words):

- Rain Gauge
- Contour
- Interpolation
- Extrapolation
- Raster/Rasterizing