**How Fast is** $H\_{2}O$ **decreasing?**

Students will be working in groups to find the relationship between weight of water versus the time water drains completely from the funnel.

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**OBJECTIVES**

* Record weight versus time data for a draining funnel.
* Describe the data using concepts of intercept and slope of a linear function.

**MATERIALS**

* TI-Nspire handheld or computer and TI-Nspire software
* Vernier Force Sensor
* Funnel
* String
* Bucket
* Water (1 liter for each group)

**PROCEDURE**

1. Set the range switch on the Force Sensor to 10 N. Connect the Force Sensor to the data- collection interface. Connect the interface to the TI-Nspire handheld or computer.
2. Choose New Experiment from the Experiment menu to set up DataQuest for data collection.
3. Arrange the Force Sensor and funnel for data collection (see Figure 1).
4. Place a cup or bucket on the floor to catch water as it drains from the funnel.
5. Block the funnel hole with your finger and fill the funnel completely with water. How long will it take for the funnel to drain? Remove your finger from the funnel hole and estimate the time required for the funnel to empty. Make a note of the time in seconds; you will need this value later.
6. If the drain time for your funnel is more than three seconds, you will use the default data- collection rate (The number of points collected should be 501); skip to Step 7. If the estimated time to drain the funnel is less than three seconds, adjust the data collection time as described below.

a. Choose Collection Setup from the Experiment menu.
b. Enter **5** as the duration (seconds). The number of points collected should be 251. c. Select OK.

1. In this activity you only want to measure the weight of the water in the funnel. To do this, you need to set the force scale so that the Force Sensor reads zero when supporting the weight of the empty funnel and string.
	1. Hold the sensor so that the funnel can hang downward from the hook. Place the bucket under the funnel. Allow the funnel to stop swinging.
	2. Ensure that the funnel is not swinging and choose Set Up Sensors ► Zero from the Experiment menu. This will set the current weight reading to zero.
2. You are now ready to collect weight versus time data.
	1. Block the funnel hole with a finger, and fill the funnel completely with water.
	2. Start data collection.
	3. When the first data point appears on the screen, remove your finger from the funnel and allow it to empty. Take care to not touch the funnel while it is emptying, and make sure that it does not swing.
	4. After data collection is complete you will see a graph of the weight of the water in the funnel versus time.
3. Your graph should be a uniformly decreasing function, with a horizontal section at the end. If you need to repeat data collection, repeat Step 8.

10. Since data collection probably did not exactly coincide with the emptying of the funnel, you need to remove the data taken before you released the water and after the funnel was empty.

a. Select the smoothly decreasing portion of the graph.

b. Choose Strike Data ► Outside Selected Region from the Data menu.

c. The data outside the region you just marked will be removed.

d. Choose Autoscale Now from the Graph menu.

**DATA TABLE**

|  |  |  |  |
| --- | --- | --- | --- |
| $$x\_{1}$$ |  | $$y\_{1}$$ |  |
| $$x\_{2}$$ |  | $$y\_{2}$$ |  |
| slope |
| x-intercept |  | y-intercept |  |

**NOW ANALYZE**

1. Click any point on the graph. Use ► and ◄ to trace across the graph. Choose two well- separated points on the graph. Record their x and y coordinates in your data table.
2. Use the two points to find the slope of the weight *vs*. time graph. Record the slope, with units, in the data table. (Answer Analysis Question #1).
3. You will need to find the y-intercept of this segment, but you can’t just trace to the y axis because the data doesn’t necessarily go that far. However, using the definition of slope we can write down the point-slope form of a line, or $y-y\_{1}=m\left(x-x\_{1}\right).$ Here y and x are variables, m the slope, and $x\_{1}$ and $y\_{1}$ are the values of a point on the line. Use this relation to answer Analysis Question 2.
4. Create a Graphs page so you can model the graph with a linear function.
	1. Insert a Graphs page.
	2. Insert the Sensor Console in order to input the graph from DataQuest. Verify that your data appears and then close the Sensor Console.
	3. Choose Zoom – Data from the Window/Zoom menu to view all of your data.
	4. Chose Function from the Graph Type menu.
	5. Enter your model equation into the Entry Line replacing *m* and *b* with the values you determined earlier.

*f1*(*x*) = *mx + b*

1. Experiment with your movable line to find the best value for *m* and *b* by grasping the line to translate and rotate it. Answer Analysis Question 3.
2. Determine the *x* intercept for the linear equation you have found. Record the value in your data table, including units. Answer Analysis Question 4.
3. You can have DataQuest perform a linear regression, a type of least-squares regression, on all the data points.
	1. Return to your DataQuest page
	2. Choose Curve Fit ► Linear from the Analyze menu.
	3. Use the parameters *m* and *b* to answer Analysis Questions 5–7. d. (optional) Print your graph.

**ANALYSIS QUESTIONS**

1. Why is the value of the slope negative?
2. Write the equation of the line fitting the data in the traditional *y* = *mx* + *b* form. Record the *y*-intercept in your data table.
3. Is your line a good fit for the data? Does the line pass directly through any particular points? Why?
4. What is the physical interpretation of the *x*-intercept?
5. Is the line suggested by the regression consistent with your results you calculated above? Why might they be different?
6. What physical characteristics of the funnel could be changed to reduce the rate at which the volume of water in the funnel is changing with time? What would happen to the slope of the fitted line to data taken with the modified funnel?

\*This activity was modified by http://www.vernier.com/files/sample\_labs/RWV-04-DQ-funnel\_volumes.pdf.