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Problem Set

1. A student performs an experiment to calculate the specific heat capacity of copper. The student experimentally finds the answer 0.340 J/g˚C. Looking up the accurate published value it is found to be 0.385 J/g˚C. Solve for the student's percent error.

$$\text{Percent error} = \left|\frac{\text{Experimental} - \text{True}}{\text{True}}\right| \times 100\ \%$$

2. Since 1965, dimes are composed of copper with 25% nickel on the outside. A Roosevelt Type dime (1946 to 1964), designed by John R Sinnockis, is composed of 90.0% silver and 10.0% copper. The composition changed when the dime cost more in silver than it was worth. A 1963 dime is weighed on ten different balances, and the mass is recorded.

Balance Number	**Mass (g) = x_m**	**$d = x_m - \bar{x}$**	**d^2**
1	2.495 g		
2	2.509 g		
3	2.507 g		
4	2.511 g		
5	2.508 g		
6	2.538 g		
7	2.512 g		
8	2.501 g		
9	2.510 g		
10	2.490 g		

a) Solve for the average value, $\bar{x}$**:** ________________________

b) Fill in the chart for all the d and d^2 values.

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c) Solve for the standard deviation, s.

$$s = \sqrt{\frac{\sum d^2}{n-1}}$$

d) Solve for the range, $\bar{x} \pm 2s$.

e) Check all data points against the range. Identify values outside the range that may be unreliable and discarded:

f) Do you suspect the differing values are due to random errors or systematic errors or possibly both? Explain. How might you test your hypothesis?

g) Solve for the new average value, $\bar{x}$, removing values outside the range in part (e).

Note: Once unreliable data points are discarded the process should be repeated to recalculate $\bar{x}$, d, s, and range values. Only the recalculation of $\bar{x}$ is required for the problem set today, but you are encouraged to recalculate d, s and range on your own.

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3a) A student determines the concentration of a sodium hydroxide solution by titration with standardized KHP. S/he obtains the values: 0.190 M, 0.202 M, and 0.205 M. Should the value 0.190 M be rejected? Apply the *Q Test*. For three values Q must be greater than 0.94 to reject the number.

$$Q = \left|\frac{\text{suspect} - \text{nearest}}{\text{largest} - \text{smallest}}\right|$$

b) The student decides to repeat the experiment two more times. The five values now include: 0.190 M, 0.202 M, 0.205 M, 0.201M and 0.203M. Use the *Q Test* to see if the first value may be rejected. For five values Q must be greater than 0.64 to reject the number.

c) Solve for the average Molarity of the measurements from part b with and without the rejected number. Is there value in repeating an experiment several times?

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4. (Take home assignment). A set of solution densities as a function of weight/volume % sugar is given below. Note that weight/volume % sugar refers to how many grams of sugar per 100 mL of solution. As an example, 9.000 % means that there are 9.000 g of sugar per 100 mL of solution. Use Excel® (or similar program) to construct a density (y-axis) versus weight/volume % sugar (x-axis) plot. Add a linear fit through the Add Trendline function and display the equation and the r^2 value on your chart. Examine your r^2 value and your plot. You will notice, upon visual inspection, that there are four data points that can be considered outliers. Remove these data points, one set at a time by highlighting and then deleting the x,y values on the columns. As you delete the outliers, one data set at a time, you will see that the graph, the equation and the r^2 change accordingly. Note how the r^2 value changes. By the last deletion, you will now have an r^2 value that is generally acceptable.

   Print out two graphs, *(1) use all data points, (2) without all four outliers*, and submit to your instructor in lab next week. Graphs should conform to the five guidelines given in the introduction.

   Display the equation and r^2 value.

weight/volume % sugar	density of solution (g/mL)
0.00	0.998
2.007	1.017
3.070	1.002
4.000	1.009
5.010	1.008
6.094	1.036
6.991	1.017
8.008	1.020
9.000	1.028
10.00	1.030
11.12	1.033
12.11	1.053
13.01	1.041
15.00	1.050
16.00	1.055
17.02	1.055
18.00	1.056
19.00	1.060
21.03	1.071
23.05	1.066
24.02	1.080