Akron-Canton Section

ASQ
AMERICAN SOCIETY FOR QUALITY™

# Steps to Prepare a Science Fair Project and Data Analysis

- **Wadsworth High School**
- **February 5, 2008**

# Select a Topic

- A science fair project is an experiment you do to find an answer to a question.
- It is not showing what you already know about something.

# Gather Background Info

- Look for information about your topic area in:
  - Books
  - Magazines
  - Internet
  - People
  - Companies
- Keep a record of where you got your information. Start a Journal NOW

# Scientific Method

- State the purpose of your experiment.
- Select a variable (something you will change or vary) that will help you find your answer.
- State your hypothesis – your guess about what the answer will be.
- Decide on and describe how you will change the variable you have selected.
- Decide on and describe how you will measure your results.

# Run Controlled Experiment and Record Data

- Perform the experiment as described in the previous step.
- Decide on what data you will collect (in god we trust, all others must bring measurement data). Record the data at the time of collection.
- Make sure that only the variable you've selected to test actually changes; try to keep everything else the same.
- Always replicate your experiment to ensure that the data collected is repeatable.
- Keep notes in one place (In the Journal).
- Write down everything you can think of, that you may need later.

# Example of data collection

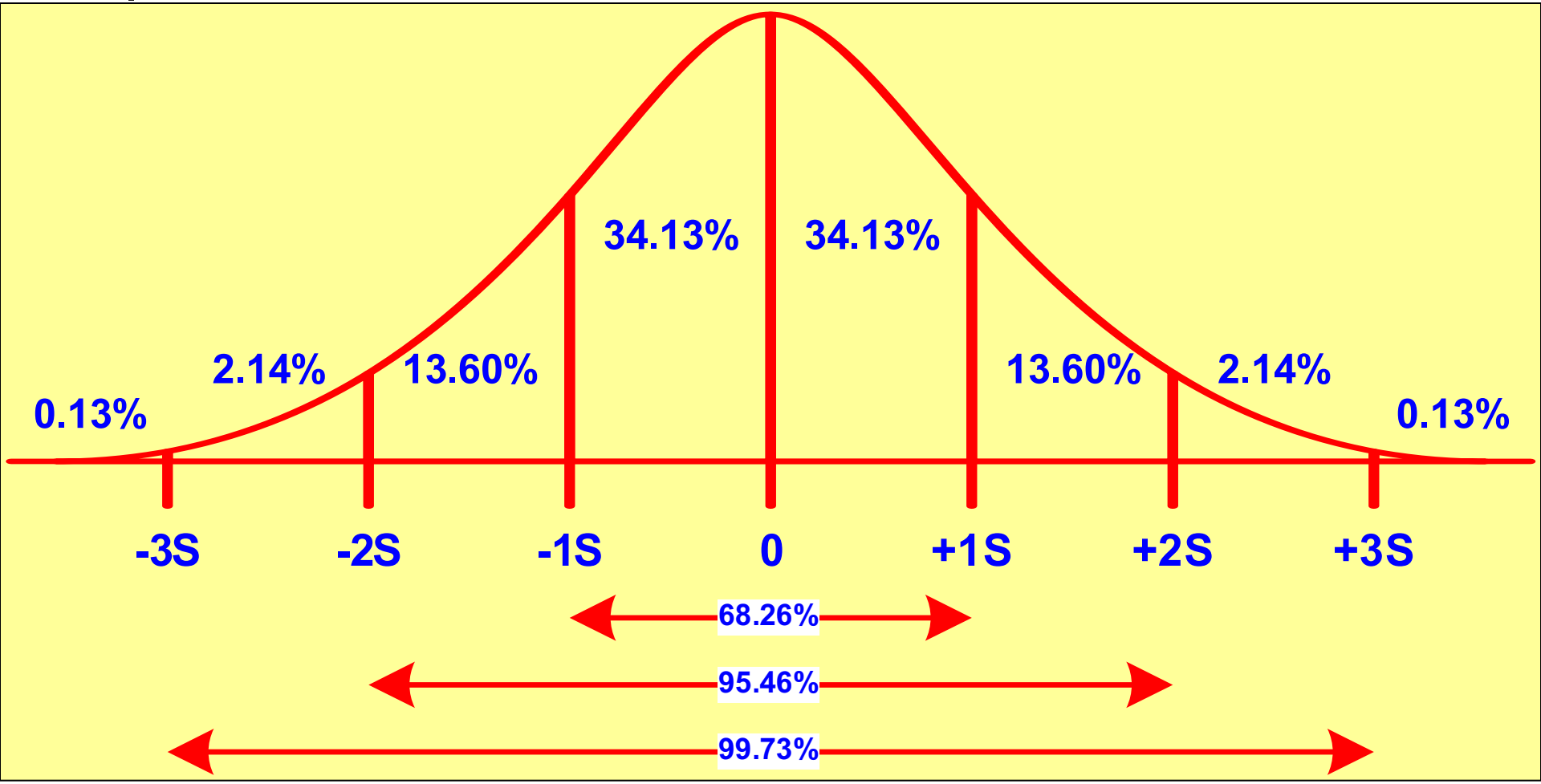
| Trial | Experiment 1 | Experiment 2 | Experiment 3 |
|---|---|---|---|
| 1 | 5.02 | 5.05 | 5.06 |
| 2 | 5.09 | 5.06 | 5.06 |
| 3 | 5.02 | 5.04 | 5.06 |
| 4 | 5.02 | 5.10 | 5.00 |
| 5 | 5.04 | 5.03 | 5.03 |
| Average | 5.037 | 5.058 | 5.044 |
| Standard Deviation | 0.029 | 0.026 | 0.026 |

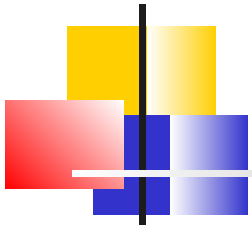
1. **Power of averaging.**
2. **Replication of experimental data.**
3. **Simple Statistics.**

# Simple Statistics: (Sample Standard Deviation)

$$s = \sqrt{\frac{\sum_{i=1}^{i=n} (\bar{x} - x_i)^2}{n-1}}$$

# Simple Statistics: (Sample Standard Deviation)





**Simple Statistics: (z-Table)**

$$z = \frac{x - \mu}{\sigma}$$

## Areas Under the Normal Curve

### z - Table

| z | 0 | 0.01 | 0.02 | 0.03 | 0.04 | 0.05 | 0.06 | 0.07 | 0.08 | 0.09 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0.00000 | 0.00399 | 0.00798 | 0.01197 | 0.01595 | 0.01994 | 0.02392 | 0.02790 | 0.03188 | 0.03586 |
| 0.1 | 0.03983 | 0.04380 | 0.04776 | 0.05172 | 0.05567 | 0.05962 | 0.06356 | 0.06749 | 0.07142 | 0.07535 |
| 0.2 | 0.07926 | 0.08317 | 0.08706 | 0.09095 | 0.09483 | 0.09871 | 0.10257 | 0.10642 | 0.11026 | 0.11409 |
| 0.3 | 0.11791 | 0.12172 | 0.12552 | 0.12930 | 0.13307 | 0.13683 | 0.14058 | 0.14431 | 0.14803 | 0.15173 |
| 0.4 | 0.15542 | 0.15910 | 0.16276 | 0.16640 | 0.17003 | 0.17364 | 0.17724 | 0.18082 | 0.18439 | 0.18793 |
| 0.5 | 0.19146 | 0.19497 | 0.19847 | 0.20194 | 0.20540 | 0.20884 | 0.21226 | 0.21566 | 0.21904 | 0.22240 |
| 0.6 | 0.22575 | 0.22907 | 0.23237 | 0.23565 | 0.23891 | 0.24215 | 0.24537 | 0.24857 | 0.25175 | 0.25490 |
| 0.7 | 0.25804 | 0.26115 | 0.26424 | 0.26730 | 0.27035 | 0.27337 | 0.27637 | 0.27935 | 0.28230 | 0.28524 |
| 0.8 | 0.28814 | 0.29103 | 0.29389 | 0.29673 | 0.29955 | 0.30234 | 0.30511 | 0.30785 | 0.31057 | 0.31327 |
| 0.9 | 0.31594 | 0.31859 | 0.32121 | 0.32381 | 0.32639 | 0.32894 | 0.33147 | 0.33398 | 0.33646 | 0.33891 |
| 1 | 0.34134 | 0.34375 | 0.34614 | 0.34849 | 0.35083 | 0.35314 | 0.35543 | 0.35769 | 0.35993 | 0.36214 |
| 1.1 | 0.36433 | 0.36650 | 0.36864 | 0.37076 | 0.37286 | 0.37493 | 0.37698 | 0.37900 | 0.38100 | 0.38298 |
| 1.2 | 0.38493 | 0.38686 | 0.38877 | 0.39065 | 0.39251 | 0.39435 | 0.39617 | 0.39796 | 0.39973 | 0.40147 |
| 1.3 | 0.40320 | 0.40490 | 0.40658 | 0.40824 | 0.40988 | 0.41149 | 0.41309 | 0.41466 | 0.41621 | 0.41774 |
| 1.4 | 0.41924 | 0.42073 | 0.42220 | 0.42364 | 0.42507 | 0.42647 | 0.42785 | 0.42922 | 0.43056 | 0.43189 |
| 1.5 | 0.43319 | 0.43448 | 0.43574 | 0.43699 | 0.43822 | 0.43943 | 0.44062 | 0.44179 | 0.44295 | 0.44408 |
| 1.6 | 0.44520 | 0.44630 | 0.44738 | 0.44845 | 0.44950 | 0.45053 | 0.45154 | 0.45254 | 0.45352 | 0.45449 |
| 1.7 | 0.45543 | 0.45637 | 0.45728 | 0.45818 | 0.45907 | 0.45994 | 0.46080 | 0.46164 | 0.46246 | 0.46327 |
| 1.8 | 0.46407 | 0.46485 | 0.46562 | 0.46638 | 0.46712 | 0.46784 | 0.46856 | 0.46926 | 0.46995 | 0.47062 |
| 1.9 | 0.47128 | 0.47193 | 0.47257 | 0.47320 | 0.47381 | 0.47441 | 0.47500 | 0.47558 | 0.47615 | 0.47670 |
| 2 | 0.47725 | 0.47778 | 0.47831 | 0.47882 | 0.47932 | 0.47982 | 0.48030 | 0.48077 | 0.48124 | 0.48169 |
| 2.1 | 0.48214 | 0.48257 | 0.48300 | 0.48341 | 0.48382 | 0.48422 | 0.48461 | 0.48500 | 0.48537 | 0.48574 |
| 2.2 | 0.48610 | 0.48645 | 0.48679 | 0.48713 | 0.48745 | 0.48778 | 0.48809 | 0.48840 | 0.48870 | 0.48899 |
| 2.3 | 0.48928 | 0.48956 | 0.48983 | 0.49010 | 0.49036 | 0.49061 | 0.49086 | 0.49111 | 0.49134 | 0.49158 |
| 2.4 | 0.49180 | 0.49202 | 0.49224 | 0.49245 | 0.49266 | 0.49286 | 0.49305 | 0.49324 | 0.49343 | 0.49361 |
| 2.5 | 0.49379 | 0.49396 | 0.49413 | 0.49430 | 0.49446 | 0.49461 | 0.49477 | 0.49492 | 0.49506 | 0.49520 |
| 2.6 | 0.49534 | 0.49547 | 0.49560 | 0.49573 | 0.49585 | 0.49598 | 0.49609 | 0.49621 | 0.49632 | 0.49643 |
| 2.7 | 0.49653 | 0.49664 | 0.49674 | 0.49683 | 0.49693 | 0.49702 | 0.49711 | 0.49720 | 0.49728 | 0.49736 |
| 2.8 | 0.49744 | 0.49752 | 0.49760 | 0.49767 | 0.49774 | 0.49781 | 0.49788 | 0.49795 | 0.49801 | 0.49807 |
| 2.9 | 0.49813 | 0.49819 | 0.49825 | 0.49831 | 0.49836 | 0.49841 | 0.49846 | 0.49851 | 0.49856 | 0.49861 |
| 3 | 0.49865 | 0.49869 | 0.49874 | 0.49878 | 0.49882 | 0.49886 | 0.49889 | 0.49893 | 0.49896 | 0.49900 |

# Simple Statistics: (Student's t-Table)

$$t = \frac{\bar{x} - \mu}{s/\sqrt{n}}$$

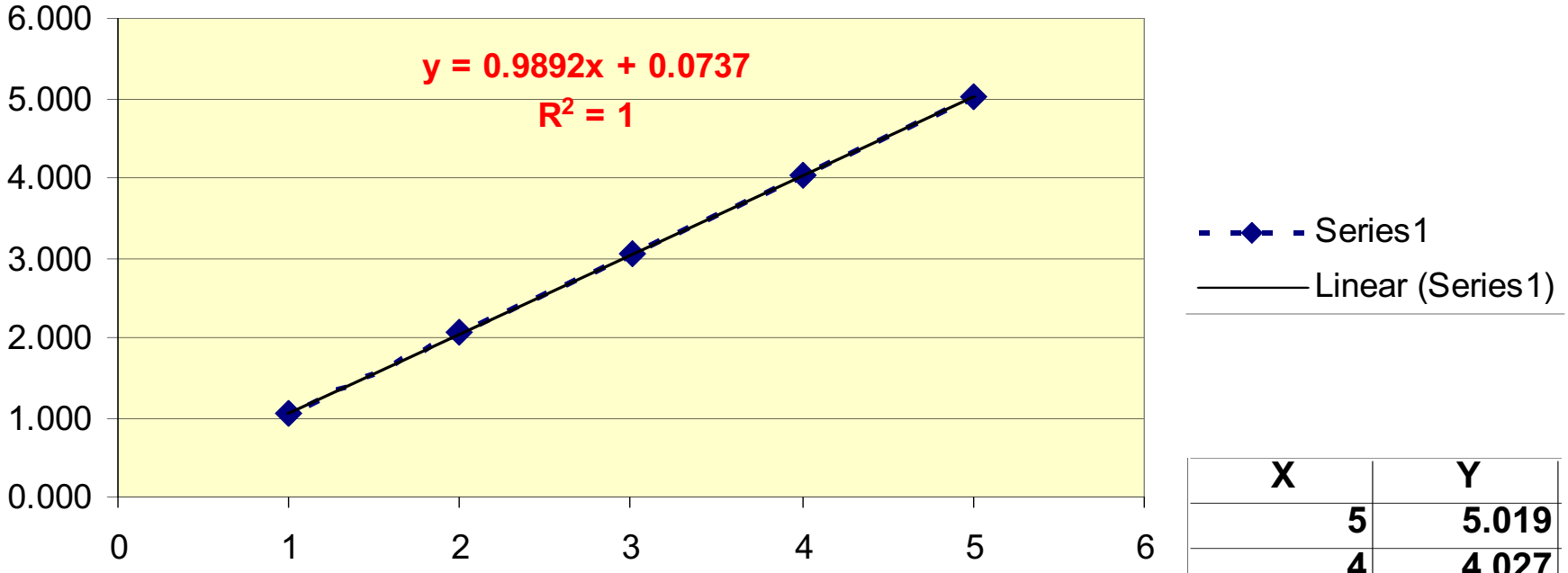
Student's t Distribution

| One -Tail Probability | 0.1 | 0.05 | 0.025 | 0.01 | 0.005 |
|---|---|---|---|---|---|
| Two-Tail Probability | 0.2 | 0.1 | 0.05 | 0.02 | 0.01 |
| Degrees of Freedom | | | | | |
| 1 | 3.07768 | 6.31375 | 12.70620 | 31.82052 | 63.65674 |
| 2 | 1.88562 | 2.91999 | 4.30265 | 6.96456 | 9.92484 |
| 3 | 1.63774 | 2.35336 | 3.18245 | 4.54070 | 5.84091 |
| 4 | 1.53321 | 2.13185 | 2.77645 | 3.74695 | 4.60409 |
| 5 | 1.47588 | 2.01505 | 2.57058 | 3.36493 | 4.03214 |
| 6 | 1.43976 | 1.94318 | 2.44691 | 3.14267 | 3.70743 |
| 7 | 1.41492 | 1.89458 | 2.36462 | 2.99795 | 3.49948 |
| 8 | 1.39682 | 1.85955 | 2.30600 | 2.89646 | 3.35539 |
| 9 | 1.38303 | 1.83311 | 2.26216 | 2.82144 | 3.24984 |
| 10 | 1.37218 | 1.81246 | 2.22814 | 2.76377 | 3.16927 |
| 11 | 1.36343 | 1.79588 | 2.20099 | 2.71808 | 3.10581 |
| 12 | 1.35622 | 1.78229 | 2.17881 | 2.68100 | 3.05454 |
| 13 | 1.35017 | 1.77093 | 2.16037 | 2.65031 | 3.01228 |
| 14 | 1.34503 | 1.76131 | 2.14479 | 2.62449 | 2.97684 |
| 15 | 1.34061 | 1.75305 | 2.13145 | 2.60248 | 2.94671 |
| 16 | 1.33676 | 1.74588 | 2.11991 | 2.58349 | 2.92078 |
| 17 | 1.33338 | 1.73961 | 2.10982 | 2.56693 | 2.89823 |
| 18 | 1.33039 | 1.73406 | 2.10092 | 2.55238 | 2.87844 |
| 19 | 1.32773 | 1.72913 | 2.09302 | 2.53948 | 2.86093 |
| 20 | 1.32534 | 1.72472 | 2.08596 | 2.52798 | 2.84534 |
| 21 | 1.32319 | 1.72074 | 2.07961 | 2.51765 | 2.83136 |
| 22 | 1.32124 | 1.71714 | 2.07387 | 2.50832 | 2.81876 |
| 23 | 1.31946 | 1.71387 | 2.06866 | 2.49987 | 2.80734 |
| 24 | 1.31784 | 1.71088 | 2.06390 | 2.49216 | 2.79694 |
| 25 | 1.31635 | 1.70814 | 2.05954 | 2.48511 | 2.78744 |
| 26 | 1.31497 | 1.70562 | 2.05553 | 2.47863 | 2.77871 |
| 27 | 1.31370 | 1.70329 | 2.05183 | 2.47266 | 2.77068 |
| 28 | 1.31253 | 1.70113 | 2.04841 | 2.46714 | 2.76326 |
| 29 | 1.31143 | 1.69913 | 2.04523 | 2.46202 | 2.75639 |
| 30 | 1.31042 | 1.69726 | 2.04227 | 2.45726 | 2.75000 |
| 40 | 1.30308 | 1.68385 | 2.02108 | 2.42326 | 2.70446 |
| 60 | 1.29582 | 1.67065 | 2.00030 | 2.39012 | 2.66028 |
| 120 | 1.28865 | 1.65765 | 1.97993 | 2.35782 | 2.61742 |

# Graphs and Charts

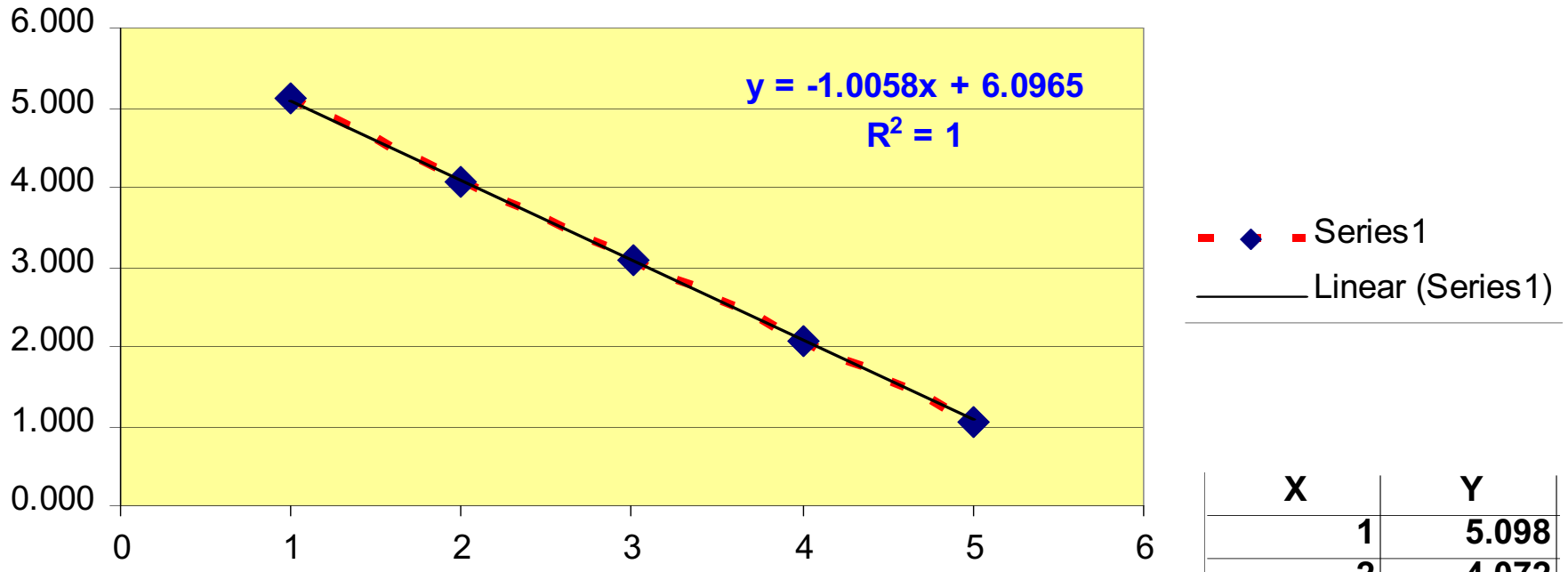
- What happened?
- Answer that question, then put the results in graphs or charts (a picture is worth a thousand words).
- Think of what presentation format will be easiest to explain and provide a clear communication of the results.
- Consider using comparative line graphs, bar charts, pie charts, and tables of data.

# Example of Chart showing Direct Correlation (Regression Analysis)



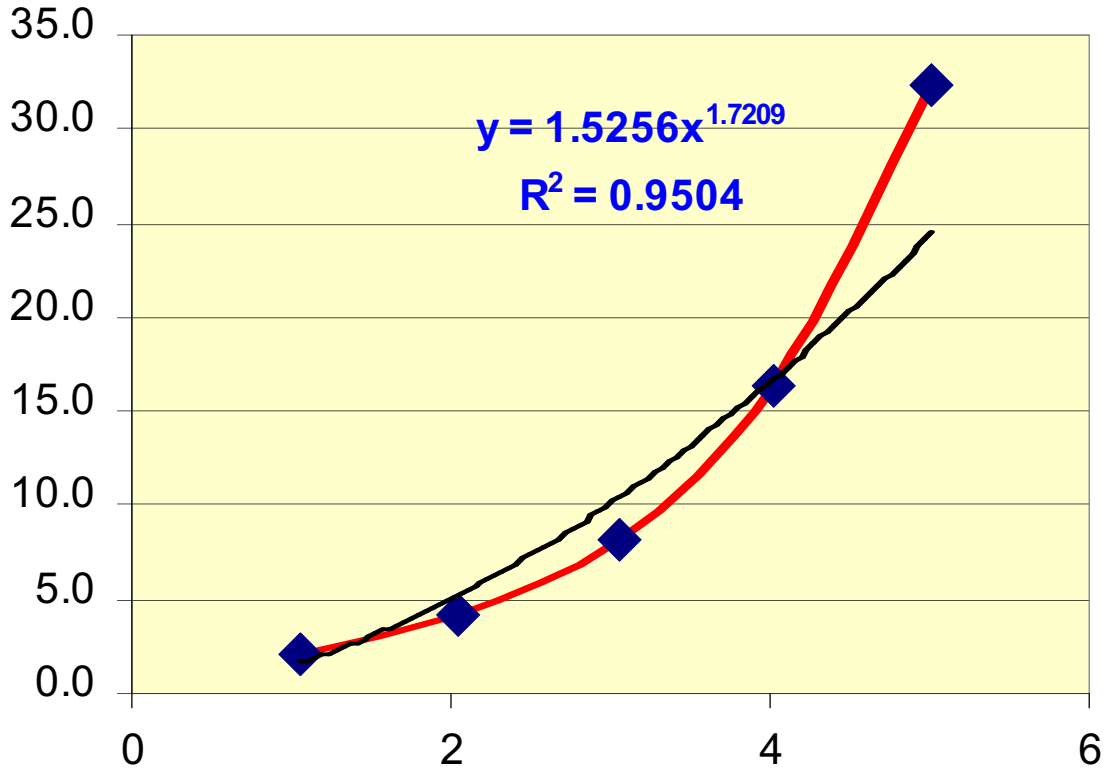

| X | Y |
|---|---|
| 5 | 5.019 |
| 4 | 4.027 |
| 3 | 3.046 |
| 2 | 2.056 |
| 1 | 1.059 |

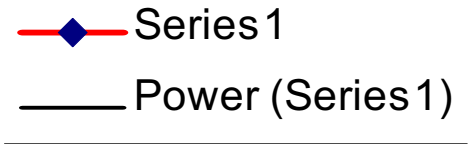
# Example of Chart showing Indirect Correlation (Regression Analysis)



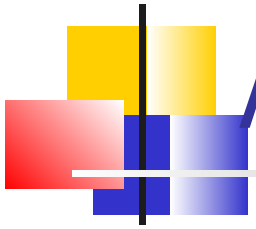

| X | Y |
|---|---|
| 1 | 5.098 |
| 2 | 4.072 |
| 3 | 3.079 |
| 4 | 2.080 |
| 5 | 1.065 |

# Example of Chart showing Non-linear relationship (Regression Analysis)




| X | Y |
|---|---|
| 5 | 32.4 |
| 4 | 16.3 |
| 3 | 8.3 |
| 2 | 4.2 |
| 1 | 2.1 |



# ANOVA TEST

- Analysis of Variance (ANOVA) test to compare if two means are the same.

# ANOVA TEST

| n | Test A | Test B |
|---|---|---|
| 1 | 1.00002 | 0.9996 |
| 2 | 0.99998 | 0.9998 |
| 3 | 1.00003 | 1.0000 |
| 4 | 0.99997 | 1.0003 |
| 5 | 1.00002 | 1.0000 |
| 6 | 1.00001 | 1.0001 |
| 7 | 1.00004 | 1.0005 |
| 8 | 1.00001 | 1.0000 |
| 9 | 1.00004 | 0.9995 |
| 10 | 0.99999 | 1.0001 |
| Sum | 10.00011355 | 9.999974474 |
| Mean | 1.000011355 | 0.999997447 |
| Standard Deviation | 2.31741E-05 | 0.000285133 |
| Variance | 5.37039E-10 | 8.1301E-08 |

# ANOVA TEST

SUMMARY

| *Groups* | *Count* | *Sum* | *Average* | *Variance* |
|---|---|---|---|---|
| Test A | 10 | 10.00011355 | 1.000011355 | 5.37039E-10 |
| Test B | 10 | 9.999974474 | 0.999997447 | 8.1301E-08 |

ANOVA

| *Source of Variation* | *SS* | *df* | *MS* | *F* | *P-value* | *F crit* |
|---|---|---|---|---|---|---|
| Between Groups | 9.67166E-10 | 1 | 9.67166E-10 | 0.023636081 | 0.879525 | 4.413873 |
| Within Groups | 7.36543E-07 | 18 | 4.0919E-08 | | | |
| | | | | | | |
| Total | 7.3751E-07 | 19 | | | | |

# F-Table

The F-Distribution (P = 0.05)

| Degrees of Freedom for Denominator (df2) | Degrees of Freedom for Numerator (df1) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 10 | 15 | 20 | 25 | 30 |
| 1 | 161.448 | 199.500 | 215.707 | 224.583 | 230.162 | 241.882 | 245.950 | 248.013 | 249.260 | 250.095 |
| 2 | 18.513 | 19.000 | 19.164 | 19.247 | 19.296 | 19.396 | 19.429 | 19.446 | 19.456 | 19.462 |
| 3 | 10.128 | 9.552 | 9.277 | 9.117 | 9.013 | 8.786 | 8.703 | 8.660 | 8.634 | 8.617 |
| 4 | 7.709 | 6.944 | 6.591 | 6.388 | 6.256 | 5.964 | 5.858 | 5.803 | 5.769 | 5.746 |
| 5 | 6.608 | 5.786 | 5.409 | 5.192 | 5.050 | 4.735 | 4.619 | 4.558 | 4.521 | 4.496 |
| 6 | 5.987 | 5.143 | 4.757 | 4.534 | 4.387 | 4.060 | 3.938 | 3.874 | 3.835 | 3.808 |
| 7 | 5.591 | 4.737 | 4.347 | 4.120 | 3.972 | 3.637 | 3.511 | 3.445 | 3.404 | 3.376 |
| 8 | 5.318 | 4.459 | 4.066 | 3.838 | 3.687 | 3.347 | 3.218 | 3.150 | 3.108 | 3.079 |
| 9 | 5.117 | 4.256 | 3.863 | 3.633 | 3.482 | 3.137 | 3.006 | 2.936 | 2.893 | 2.864 |
| 10 | 4.965 | 4.103 | 3.708 | 3.478 | 3.326 | 2.978 | 2.845 | 2.774 | 2.730 | 2.700 |
| 11 | 4.844 | 3.982 | 3.587 | 3.357 | 3.204 | 2.854 | 2.719 | 2.646 | 2.601 | 2.570 |
| 12 | 4.747 | 3.885 | 3.490 | 3.259 | 3.106 | 2.753 | 2.617 | 2.544 | 2.498 | 2.466 |
| 13 | 4.667 | 3.806 | 3.411 | 3.179 | 3.025 | 2.671 | 2.533 | 2.459 | 2.412 | 2.380 |
| 14 | 4.600 | 3.739 | 3.344 | 3.112 | 2.958 | 2.602 | 2.463 | 2.388 | 2.341 | 2.308 |
| 15 | 4.543 | 3.682 | 3.287 | 3.056 | 2.901 | 2.544 | 2.403 | 2.328 | 2.280 | 2.247 |
| 16 | 4.494 | 3.634 | 3.239 | 3.007 | 2.852 | 2.494 | 2.352 | 2.276 | 2.227 | 2.194 |
| 17 | 4.451 | 3.592 | 3.197 | 2.965 | 2.810 | 2.450 | 2.308 | 2.230 | 2.181 | 2.148 |
| 18 | 4.414 | 3.555 | 3.160 | 2.928 | 2.773 | 2.412 | 2.269 | 2.191 | 2.141 | 2.107 |
| 19 | 4.381 | 3.522 | 3.127 | 2.895 | 2.740 | 2.378 | 2.234 | 2.155 | 2.106 | 2.071 |
| 20 | 4.351 | 3.493 | 3.098 | 2.866 | 2.711 | 2.348 | 2.203 | 2.124 | 2.074 | 2.039 |
| 25 | 4.242 | 3.385 | 2.991 | 2.759 | 2.603 | 2.236 | 2.089 | 2.007 | 1.955 | 1.919 |
| 30 | 4.171 | 3.316 | 2.922 | 2.690 | 2.534 | 2.165 | 2.015 | 1.932 | 1.878 | 1.841 |
| 35 | 4.121 | 3.267 | 2.874 | 2.641 | 2.485 | 2.114 | 1.963 | 1.878 | 1.824 | 1.786 |
| 40 | 4.085 | 3.232 | 2.839 | 2.606 | 2.449 | 2.077 | 1.924 | 1.839 | 1.783 | 1.744 |
| 50 | 4.034 | 3.183 | 2.790 | 2.557 | 2.400 | 2.026 | 1.871 | 1.784 | 1.727 | 1.687 |
| | 1 | 2 | 3 | 4 | 5 | 10 | 15 | 20 | 25 | 30 |

# Construct an Exhibit Display

- It has to be neat and appealing to the eye.
- It does not have to be typed.
- Make it fun, but be sure people will clearly understand what you did.
- Show that you used the scientific method.
- Display your conclusion clearly.

# Construct an Exhibit Display

- Develop a three sided exhibit which will sit on a table – include your chart and graph.
- Put any experimental items of interest on the table top display.
- Include some photographs of you conducting the experiment.
- **Display your conclusion clearly.**
  - E.g. Conclusion is that Lysol Hard Water Stain Cleaner is the second most expensive cleaner, but the best buy because it cleans better.

# Write a Report

- Tell the story of your project – tell what you did and exactly how you did it.
- Include your references and bibliography.
- Include a journal that shows where you gathered background information and data.

# Practice Presentation to Judges

- Practice explaining your project so a parent, friend, grandparent, etc. This will help you be calm at the science fair.
- The judges will be nice and will be interested in what you did and what you learned.

# 9. Important to the Judges

- Can you demonstrate knowledge of the scientific method?
- Will you be able to reasonably answer the question you are asking by your experiment?
- Will you be enthusiastic about the project?
- Will you be able to speak knowledgeably about the subject when you are done?
- Will your results make a visually appealing display?

# 10.Come to the Science Fair

- Relax and have fun!!
- See you there!!!!

***And GOOD LUCK on Saturday, February 23, 2008.***

Akron-Canton Section

ASQ AMERICAN SOCIETY FOR QUALITY™

# Science Fair Award

- The Akron-Canton ASQ section has allocated a $50 award for the Wadsworth Science Fair for the use of statistical and quality techniques in data analysis this year.
- A team of ASQ judges will come and judge for this award.
- Any student who wants to be considered for this award may submit their names in advance.
- We will collect the names on Saturday and judge those who applied first.
- If we cannot decide on a winner from this list, we will judge other projects and award it to the best qualified entry.
- The winner is invited to our May ASQ dinner meeting with their family and present their project to the ASQ members. The winner and their family will be our guests to a complimentary dinner and will be formally presented with the $50 check at the meeting.

# Bring the State Science Fair Trophy to Wadsworth