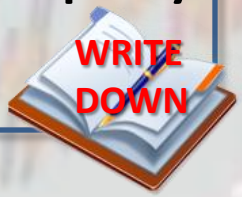
Interpreting Data

Graphing

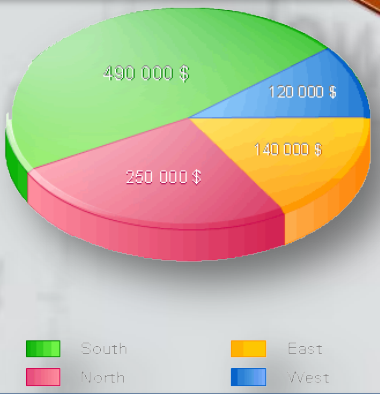
A Visual Approach

- It is said that “a picture is worth a thousand words.”
- That would explain why graphing is such a good way to present data.
- **Graphing** is a visual display of information.

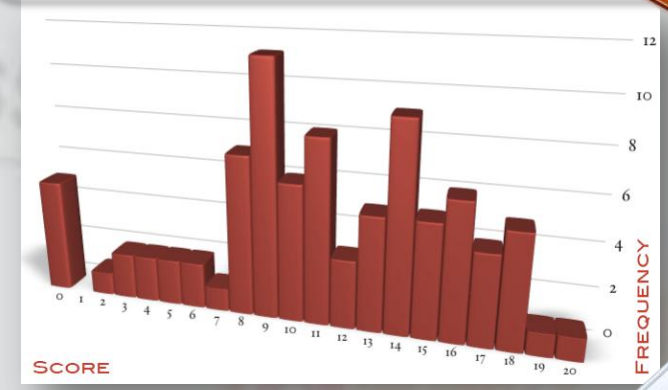


Types of Graphs

- Pie charts - show proportions



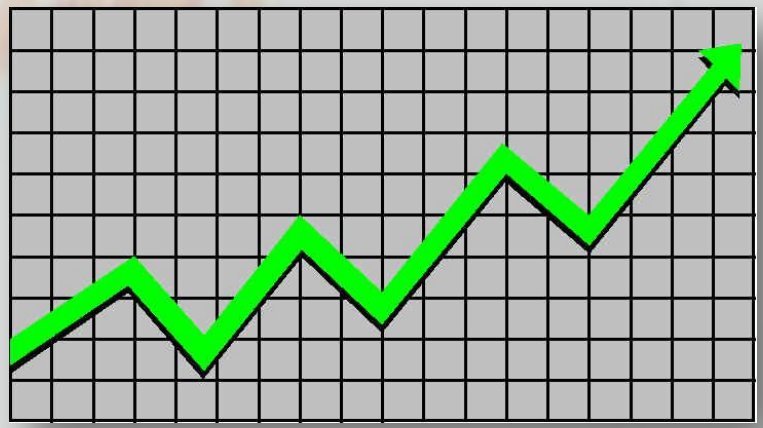
- Bar graphs *or histograms* - show discrete variables



- Pictographs - use pictures to show amounts

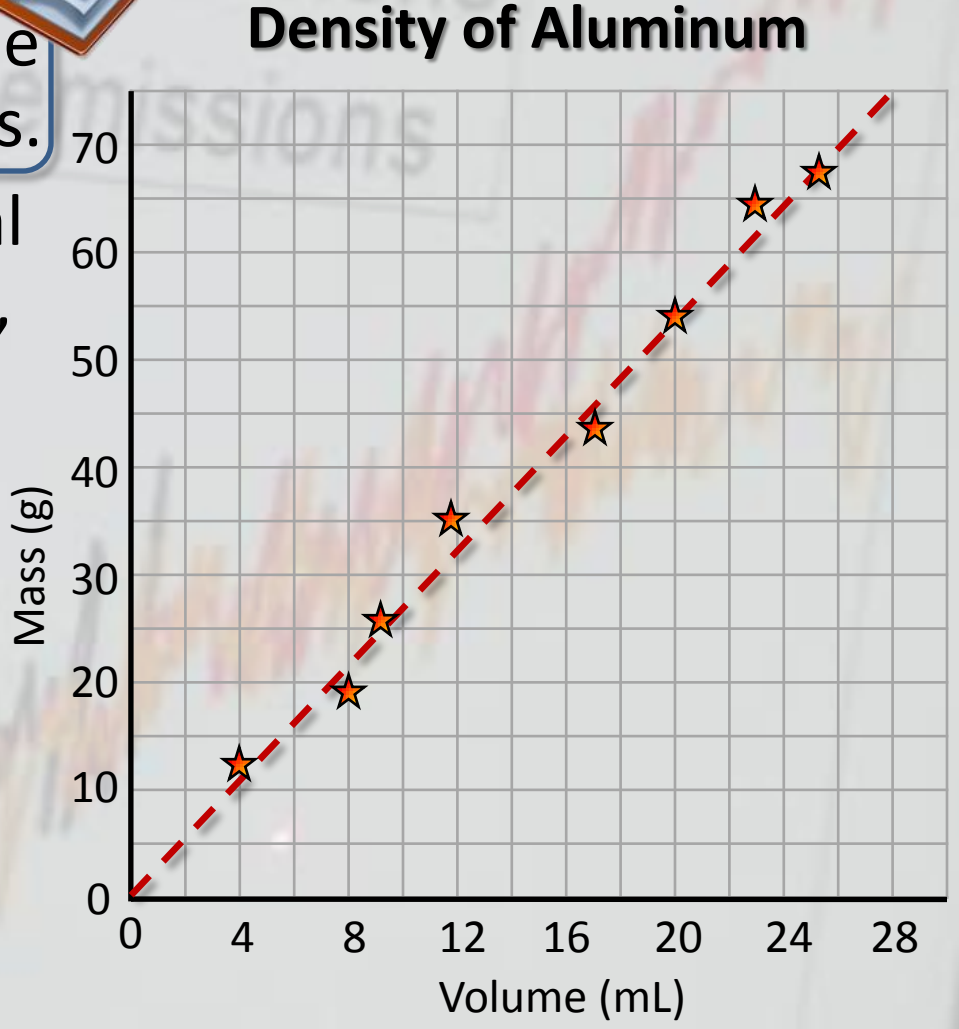
Favorite Pizza Toppings	
cheese	
mushroom	
sausage	
pepperoni	
Key	= 5 pizzas

- Line graphs – show continuous variables



Graphs in Science

- Most graphs used in the sciences are line graphs.
- To make a proper visual display for a line graph, you need to:
  - Select the axes
  - Select the origin
  - Select the interval
  - Plot the points
  - Draw the best straight line or curve



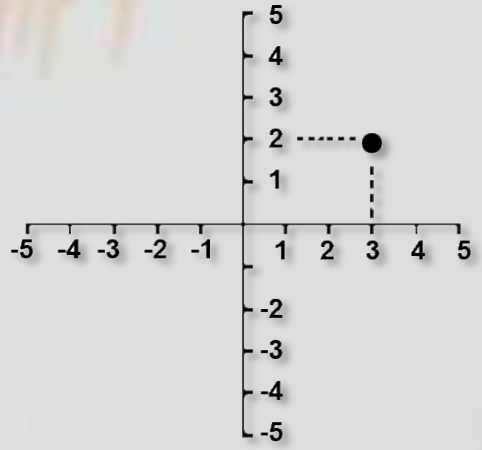
A Good Visual Display

- Remember a graph is a visual display of information.
- It is important to make a ***good*** visual display.
- If you turned on the TV and saw a tiny picture in one corner, that would not be a good visual display. It's mostly wasted space.
- An almost empty graphing space with all the data in one small area is not a good display for the same reason.
- Next, you will learn how to make a good visual display.

Selecting Axes

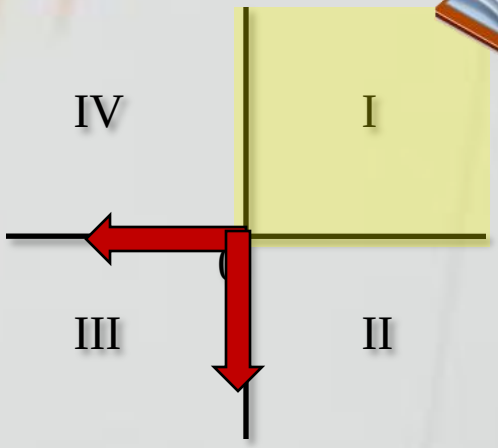
- An ***axis*** is a straight line which may have numbers or categories arranged along it.
- Graphs showing the relationship between two variables generally have two axes arranged at right angles.
  - The horizontal axis is often called the *X*-axis.
  - The vertical axis is often called the *Y*-axis.

- The two perpendicular axes form the coordinates by which any point can be located.
- The graph to the right shows the point (3,2). It is located 3 across on the *X*-axis and 2 up on the *Y*-axis



More on Selecting Axes

- Notice that the axes form four quadrants with a central point at (0,0). This central point is called the ***origin*** .
  - Points to the left of the origin have negative X-values.
  - Points below the origin have negative Y-values.
- Many of the quantities measured by scientists do not have negative values.
  - It doesn't make any sense to speak of a length, a mass, or a volume below zero.
  - A graph showing the relationship between the mass and volume of aluminum, for example, would have no negative values.
  - Graphs with only positive values have axes shaped like an "L".
    - This is the shape of the axes surrounding the quadrant in the upper right (Quadrant I).
    - All the other quadrants (Quadrant II – Quadrant IV) have places for negative values.
    - These quadrants are not displayed when they are empty so space is not wasted.



Axis Selection - An Example

- Imagine you were preparing a graph showing the relationship between the mass and volume of different amounts of aluminum.
- Your data is shown in the table to the right.
- Since all your data values are positive, they are all in *Quadrant I*.
- Your axes should be "L" shaped.

Volume (mL)	Mass (g)
4.0	12.0
8.0	19.0
9.0	26.0
11.0	35.0
17.0	43.0
20.0	54.0
23.0	64.5
25.4	67.0

Selecting an Origin

- The origin of a graph is an ***arbitrary*** point.
  - This means it is selected for convenience.
- When the data displayed on a graph have both positive and negative values, it makes sense to select the point (0,0) as the origin because it is in the middle.
- If (0,0) is one of your data points, it is important to include it on the graph and to make it the origin.
- When the graph is entirely in Quadrant I, however, points other than (0,0) may be more convenient to use as the origin.

More on Selecting an Origin

- When the range of the data is small compared to the distance from zero to the lowest data point, it is wise to use a number closer to the lowest data point as the origin rather than using zero.
  - The **range** of the data is the difference between the highest data point and the lowest data point

In the graph below you would use an origin other than zero.

Origin Selection – An Example

- Consider your data:

Volume (mL)	Mass (g)
4.0	12.0
8.0	19.0
9.0	26.0
11.0	35.0
17.0	43.0
20.0	54.0
23.0	64.5
25.4	67.0

- If you have no aluminum, the mass is zero, and the volume is zero, so (0,0) should be the origin.

Selecting an Appropriate Interval

- The space between the numbers on the axes is called an ***interval***.

- The numbers on the axes are usually spaced evenly, however, the intervals on the vertical and horizontal axes do not need to be the same.
- The intervals should be selected in such a way that the graph is spread out enough to cover the entire graphing space while leaving room for all the points to fit.
- The way the axes are numbered will depend on the size of the graph paper and the range of the graph.
- The smallest possible interval is the range divided by the number of boxes in the graphing space.
  - The range is the difference between the highest and lowest value for each variable.

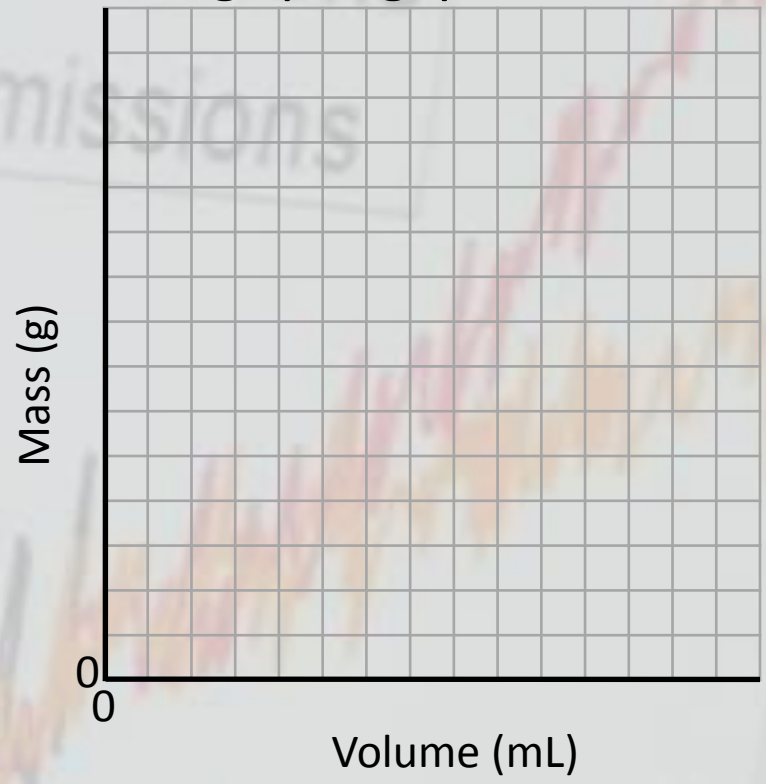
Interval Selection – An Example

- Examine the data below.

Volume (mL)	Mass (g)
4.0	12.0
8.0	19.0
9.0	26.0
11.0	35.0
17.0	43.0
20.0	54.0
23.0	64.5
25.4	67.0

- Since the origin is (0,0)
  - The X range is 25.4 – 0 = 25.4
  - The Y range is 67.0 – 0 = 67.0

- The graphing space is below.



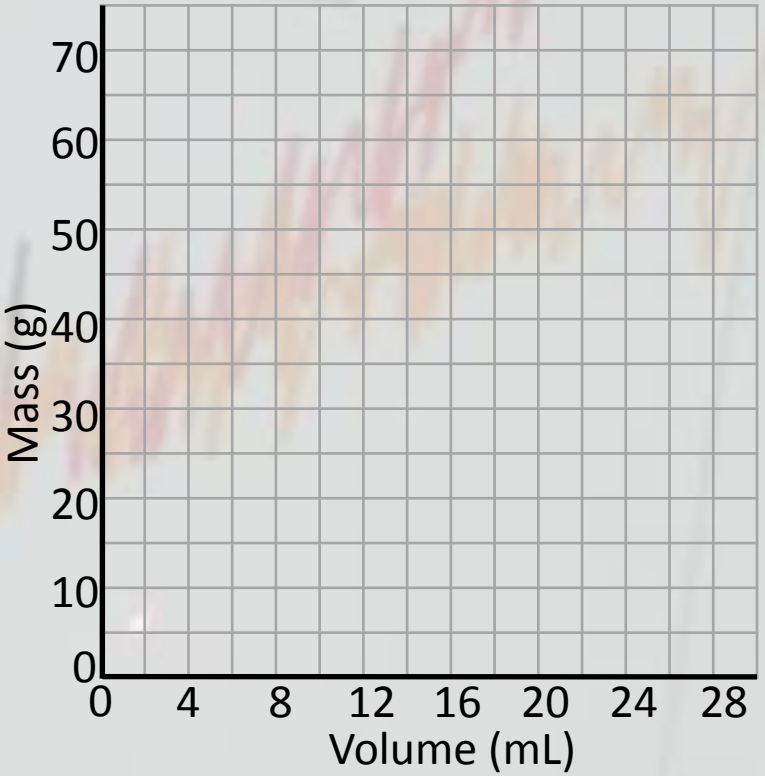
- There are 15 boxes along both the X and Y axis.

Interval Selection Continued

The ***Interval*** $\geq \frac{\textbf{Range}}{\textbf{Boxes}}$

- The X-*Interval*
  - *Interval* $\geq \frac{25.4}{15} \geq 1.7$
  - A convenient value would be 2
- The Y-Interval
  - *Interval* $\geq \frac{67.0}{15} \geq 4.5$
  - A convenient value would be 5

When the intervals are numbered it is not necessary to label every line.



Plotting the Points

- Points are plotted by locating the horizontal and vertical coordinates of each point on the axes.
- If imaginary perpendicular lines are extended through the axes at the coordinates of a point, the place where the perpendicular lines cross is where the point is plotted.

Volume (mL)	Mass (g)
4.0	12.0
8.0	19.0
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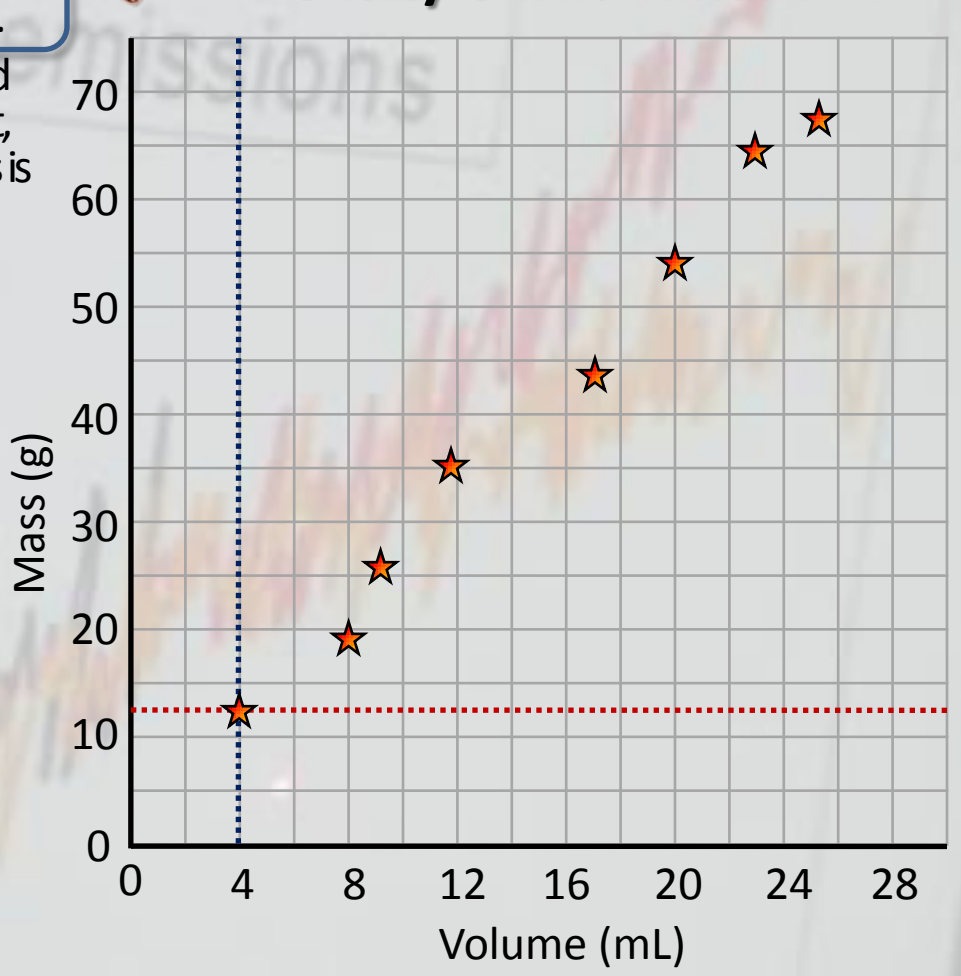
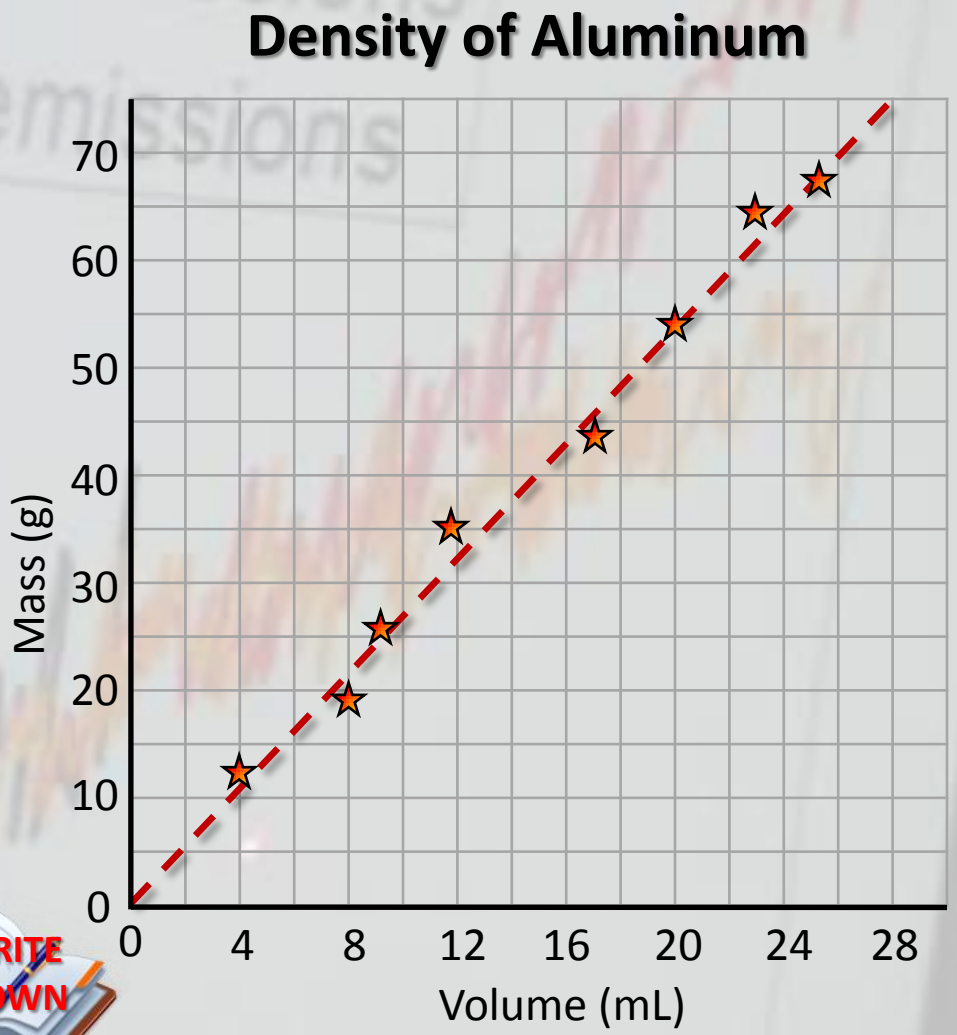


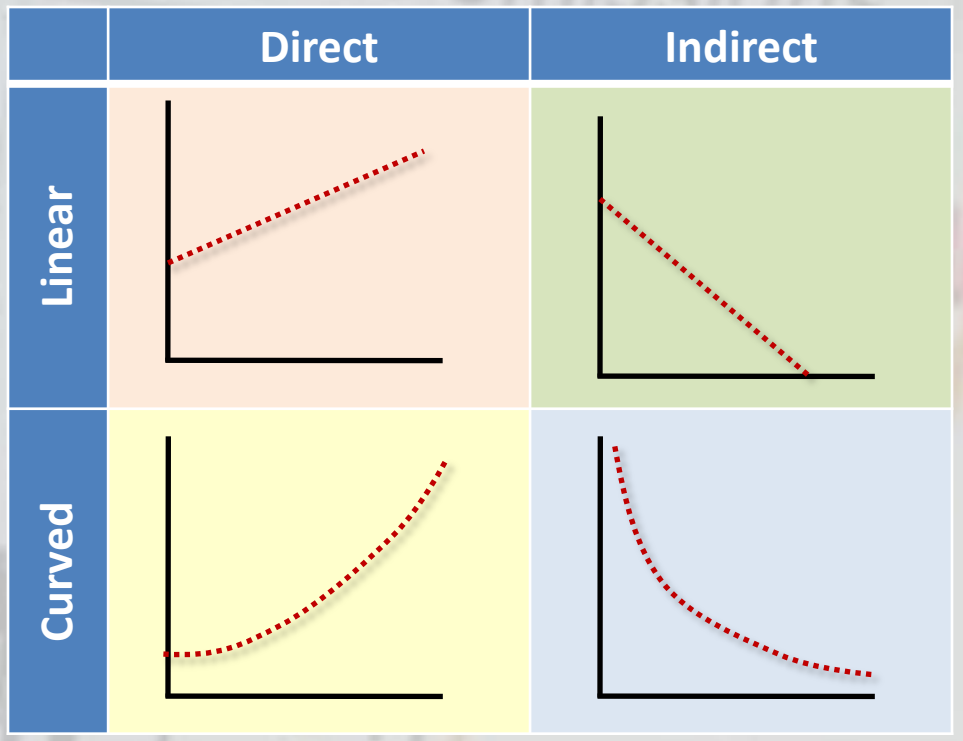
Drawing the Best Line or Curve

- Each of the points you plot represents a single measurement .
- Measurements are always imperfect.
- If the measurements were perfect, then you would connect the points as in a connect the dot drawing.
- Since each point only approximates the *TRUE* value, the points are not likely to fall directly on the line or curve.
- As a result, you need to interpret the data by drawing the best line or curve through the points.
- Errors of measurement tend to be random.
  - This means that measurements have an equal chance of being too high or too low.
  - The best line or curve is drawn in such a way that the points are distributed equally above and below it.



Interpreting Graphs - Relationships

- The four main types of relationships are shown below.



- The relationship between the mass and volume of aluminum is linear and direct.

Interpreting Graphs - Slope

- The slope (m) is the change in Y (ΔY) divided by the change in X (ΔX)
  - $m = \frac{\Delta Y}{\Delta X}$
- Select two points on the line that are easy to read.
  - $\Delta X = X_2 - X_1 = 26 - 0 = 26$
  - $\Delta Y = Y_2 - Y_1 = 70 - 0 = 70$
- The slope is:
  - $m = \frac{\Delta Y}{\Delta X} = \frac{70\ g}{26\ mL} = 2.7\ {}^{g}/_{mL}$
  - This is the density of aluminum.

An Example

Density of Aluminum