Measurements

Quantity – has magnitude, size, or amount (volume, mass, length, etc)

Unit – predefined quantity represented by a specific type of measurement
Unit Examples:

Name	Symbol	Measurement
Liter	L	Volume
Kilogram	kg	Mass
Meter	m	Length
Second	s	Time

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Measurements

- Measurements will consist of a number and a unit
  Ex: 7 meters, 3 kilograms, 15 seconds
- Units of measure have been standardized on natural values that never change.
- World uses SI system as a standard system.
- Numbers do not use commas
  2,100 can mean 2.100 in some countries

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SI System

- The SI system uses prefixes in front of base units to determine the magnitude or size. Each prefix is a certain power of 10.

Saying	Prefix	Symbol	Amount
King	kilo	k	1000
Henry	hecto	h	100
Died	deka	da	10
By	base		1
Drinking	deci	d	$^{1}/_{10}$
Chocolate	centi	c	$^{1}/_{100}$
Milk	milli	m	$^{1}/_{1000}$

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Units and Measurements

Mass is not weight!! Mass is amount of material. Weight is a measure of gravitational pull

Derived Units are measurable properties that are based on SI units multiplying or dividing each other.

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}} = \frac{g}{cm^3} = \frac{g}{mL}$$

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Comparisons of Units

Length
1 km ~ 2½ laps on the track
1 m ~ Height of a desk
1 cm ~ Width of a finger
1 mm ~ Credit card thickness

Volume
1 L ~ About 1 Quart
1 mL ~ A few drops of water (cm^3)

Mass
1 g ~ Mass of a paper clip
1 kg ~ 1 liter of water
1 ton ~ small car

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Dimensional Analysis

Math with Units

Units will follow the same rules as variables and numbers.

Going back to math…

Anything multiplied by 1 remains the same.

$A \cdot 1 = A$

Anything divided by itself equals 1 $\frac{A}{A} = 1$

If B = A Then → $\frac{B}{A} = 1$

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Conversion Factors

Applying rules to units:

Begin with a statement of equality.

3 ft = 1 yd

This means: $\frac{3\text{ ft}}{1\text{ yd}} = 1 = \frac{1\text{ yd}}{3\text{ ft}}$

These are conversion factors!!

Multiplying by either one does not change a value

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Conversion Example

How many feet are in 10 yards?

Begin with writing all statements of equality needed.

3 ft = 1 yd

Next, write the quantity to be converted.

10 yards

There are two possible conversion factors:

$\frac{3\text{ ft}}{1\text{ yd}}$ $\frac{1\text{ yd}}{3\text{ ft}}$

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Conversion Example

We want to use the factor that will allow the yards to cancel and leave the units in feet.

$10\text{ yd}\left(\frac{3\text{ ft}}{1\text{ yd}}\right) =$

Cross out the units that will cancel. Uncanceled units will remain in the answer.

Multiply the top numbers, divide by bottom numbers

$10\,\cancel{\text{yd}}\left(\frac{3\text{ ft}}{1\,\cancel{\text{yd}}}\right) = 30\text{ ft}$

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How to do a problem!

How many grams are in 3.25 kg?

1 kg = 1000 g ← Statement of Equality

$3.25\,\cancel{\text{kg}}\left(\frac{1000\text{ g}}{1\,\cancel{\text{kg}}}\right) = \boxed{3250\text{ g}}$

Units are canceled

Answer is marked

The "cross-hatch" method is also acceptable:

1 kg = 1000 g

3.25 ~~kg~~	1000 g
	1 ~~kg~~

= $\boxed{3250\text{ g}}$

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Handling Time

A separate conversion factor must be used for each step needed.

s → min → hr → day → year

Convert 5040 s into hrs.

1 min = 60 sec

1 hr = 60 min

$5040\,\cancel{\text{s}}\left(\frac{1\,\cancel{\text{min}}}{60\,\cancel{\text{s}}}\right)\left(\frac{1\text{ hr}}{60\,\cancel{\text{min}}}\right) = \boxed{1.4\text{ hrs}}$

Factor 1 Factor 2

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Converting Derived Units

A separate conversion factor is needed for each unit change. For each power of a unit, you will also need an extra conversion factor.

Convert 10 km / hr to m / min.

1 km = 1000 m

1 hr = 60 min

$$\frac{12\ \cancel{km}}{\cancel{hr}}\left(\frac{1000\ m}{1\ \cancel{km}}\right)\left(\frac{1\ \cancel{hr}}{60\ min}\right) = \boxed{200\ m / min}$$

Area and Volume

Area and Volume

Area and volume require a separate conversion factor for each power

Convert 5 m² to cm²

1 m = 100 cm

$$5\ \cancel{m^2}\left(\frac{100\ cm}{1\ \cancel{m}}\right)\left(\frac{100\ cm}{1\ \cancel{m}}\right) = \boxed{50\ 000\ cm^2}$$

Factor 1 Factor 2

Accuracy and Precision

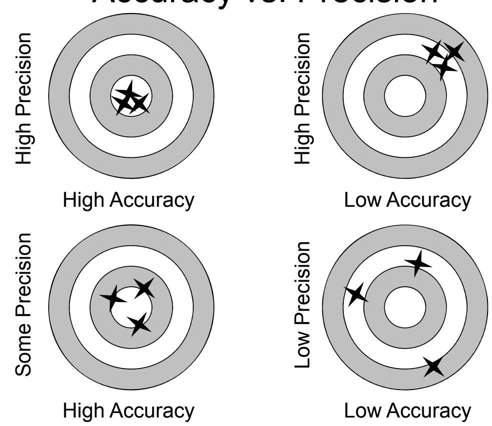
Accuracy – Closeness of a measurement to an accepted value (correctness)

Ex. Joey scored a 99 out of 100.

Precision – Closeness of a set of measurements (repeatability/consistency)

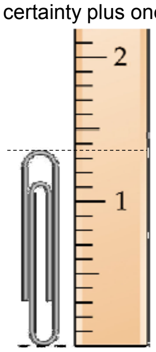
Ex. Freddy's last five test scores were 44, 45, 45, 46 and 45.

Accuracy vs. Precision



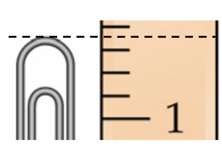
Significant Figures

Every measurement should include all digits of certainty plus one that is estimated.



The last digit of certainty is 1.3 cm

Adding one estimated digit will give us 1.3**6** cm



Sig Fig Rules

Significant Digits

All nonzero numbers

Ex. 1234.5678 → 8 sig figs

Scientific Notation is presented with all sig figs

Ex. 3.470×10^{15} → 4 sig figs

Significant Zeros

Captured Zeros – between nonzero numbers

Ex. 13**0**2.**0**5 → 6 sig figs

Trailing Zeros – to the right of a decimal

Ex. 5.3**00** → 4 sig figs

Sig Fig Rules

Not Significant Zeros

Leading Zeros – to the left of a number to hold place

Ex. **0.000**453 → 3 sig figs

Trailing Zeros – to the left of a decimal to hold place

Ex. 53**0000** → 2 sig figs

Trailing Zeros may be significant if you are told so.
Adding a decimal will make them significant.

Ex. 53**0000.** → 6 sig figs

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Special Cases with Sig Figs

"Infinite" Sig Figs

These do not have any effect on the number of sig figs in a calculation.

Conversion Factors

Ex. 3 Ft = 1 Yd

Exact Counts

Ex. 3 People (You cannot have half a person)

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Addition and Subtraction with Sig Figs

Accept the certainty of the number with the least digits to the right

```
   1 0 0.1      ---> tenths
+    1 0.0 0 1  ---> thousandths
   1 1 0.1 0 1
       ↓
   1 1 0.1 ---> sig figs to tenths place
```

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Addition and Subtraction with Sig Figs

Why does this work?

Every measurement is only allowed one digit of uncertainty.

Black → Certain

Red → Uncertain

```
   2 5.3 7 ---> hundredths
+    2.6   ---> tenths
   2 7.9 7
       ↓
   2 8.0 ---> sig figs to tenths place
Certain   Uncertain
```

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Multiplication and Division with Sig Figs

Accept the certainty of the number with the least numbers of sig figs

```
   3.4 5 2 1 9 8 ---> 7 sig figs
x            2.1 ---> 2 sig figs
7.2 4 9 6 1 5 8
    ↓
  7.2  ---> Round to 2 sig figs
```

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Multiplication and Division with Sig Figs

Why does this work?

Every measurement is only allowed one digit of uncertainty.

Black → Certain

Red → Uncertain

```
  1 0 3.7 ---> 4 sig figs
  x   2.6 ---> 2 sig figs
    6 2 2 2
  2 0 7 4 0
  2 6 9.6 2
     ↓
  2 7 0 ---> 2 sig figs
Certain  Uncertain  Placeholder
```

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Scientific Notation

10 000 → 10^4
1 000 → 10^3
100 → 10^2
10 → 10^1
1 → 10^0 → $^{10}/_{10}$
0.1 → 10^{-1} → $^{1}/_{10}$
0.01 → 10^{-2} → $^{1}/_{100}$
0.001 → 10^{-3} → $^{1}/_{1000}$
0.0001 → 10^{-4} → $^{1}/_{10000}$

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Converting Scientific Notation

Numbers greater than 1

45000 = 4.5 x 10000 = 4.5 x 10 x 10 x10 x 10
Write the leading number and its "trail"
Count the digits after the leading number
→ 4.5 x 10^4

Numbers between 0 and 1

0.0034 = 3.4 x $^{1}/_{1000}$ x = 3.4 x $^{1}/_{10}$ x $^{1}/_{10}$ x $^{1}/_{10}$
Write the leading number and its "trail"
Count the digits after the leading number
→ 3.4 x 10^{-3}

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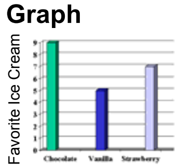
Choosing the Correct Graph

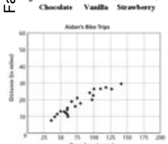
Bar Graphs

These are used when comparing the values of items or categories.



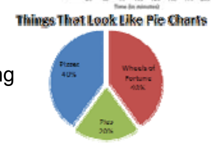
Line (Scatter) Graph

These are used when values are compared to another value such as time. This will be in a sequence.



Pie Charts

These are used when comparing parts of a whole (percentages)



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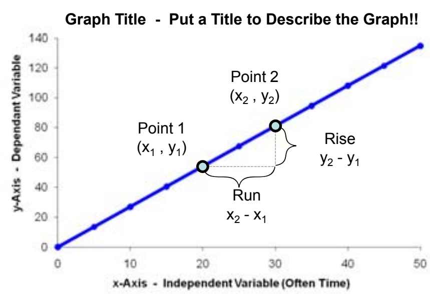
Parts of a Line Graph (Scatter Plot)

The "rise" is the change in two points along the y-axis.
The "run" is the change in two points along the x-axis.



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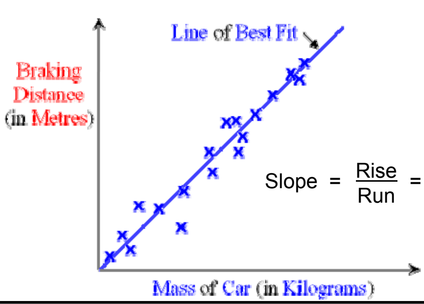
Line of Best Fit and Slope

- A line of best fit is a straight line that will come closest to all of the points.
- You can find the slope from any two points of the line



$$\text{Slope} = \frac{\text{Rise}}{\text{Run}} = \frac{Y_2 - Y_1}{X_2 - X_1}$$

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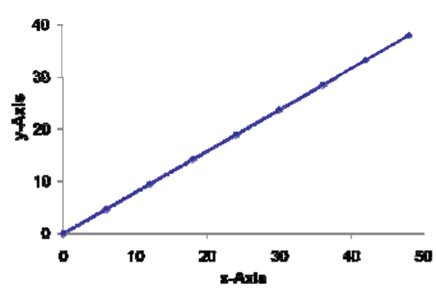
Scale

- The **scale** is the values on the x-axis & the y-axis. The numbers should be **evenly spaced** and **fit all data**.



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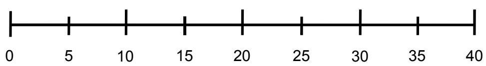
Creating the Scale

- Begin by selecting a value the is higher than your largest piece of data. This should be easy to divide up.
  Ex: If the highest value of data is 37, the scale should go up to 40 or 50. A number like 38 is hard to divide.
- Divide up your number to fit on each point on the scale.
  Ex: If you choose 40, the midpoint should be 20, and each mark could be broken by 4's, 5's, or 10's



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Graphing Tips

- **Spread** the **scales** out as far as you can on the x-axis & the y-axis. For the last point on the scale, choose a value higher than any data.
- Include **units** when labeling the x-axis & y-axis
- Create a **key** if you have multiple items on the graph.
- Do not just connect the dots!! If it appears to be a straight line, make a line that best fits the data.

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Direct Proportion

Mathematically:

$$y = kx \rightarrow \frac{y}{x} = k$$

Effect:
If one variable increases, the other increases
If one variable decreases, the other decreases

Ex.
Freddy increased his study time to increase his grade.
When he studied very little, his grade was a low number.

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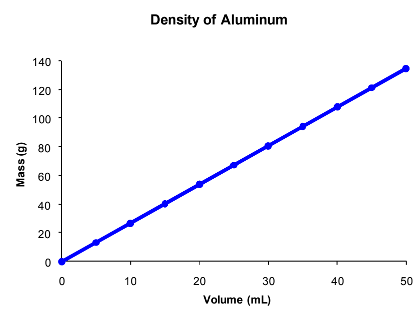
Direct Proportion Example

As volume increases, mass increases.



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Inverse Proportion

Mathematically:

$$xy = k \rightarrow y \propto \frac{1}{x}$$

$\propto$ means proportional to

Effect:
If one variable increases, the other decreases
If one variable decreases, the other increases

Ex.
Increased tooth brushing decreases cavities
Decreased tooth brushing increases cavities

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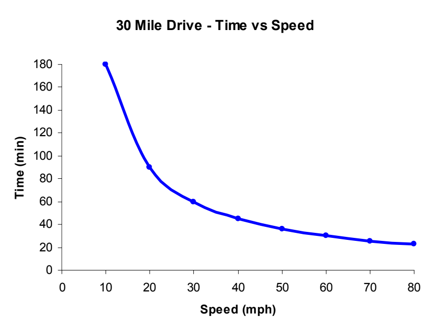
Inverse Proportion Example

As speed increases, driving time decreases.



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