2-3 Using Scientific Measurement

Section 2-3 Using Scientific Measurements

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.

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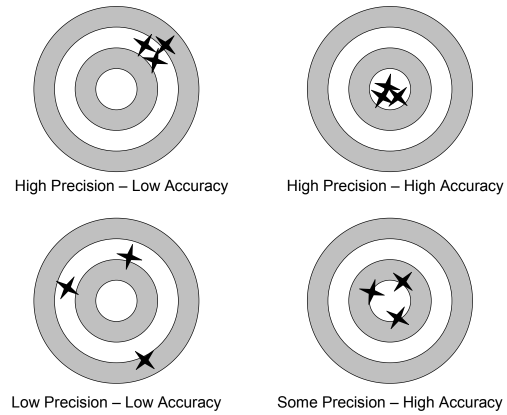
Section 2-3 Using Scientific Measurements



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Section 2-3 Using Scientific Measurements

Percent Error – Measurement of accuracy

$$= \frac{V_{accepted} - V_{measurement}}{V_{accepted}} \times 100$$

3

Section 2-3 Using Scientific Measurements

Percent Error Example

Johnny Hotcakes measured the length of a football field from end zone to end zone to be 96 yards. The accepted value is 100 yards making him off by 12 whole feet!!

What is his percent error?

$$\% \text{ Error} = \frac{V_{accepted} - V_{measurement}}{V_{accepted}} \times 100$$

$$\% \text{ Error} = \frac{100 - 96}{100} \times 100 = 4\%$$

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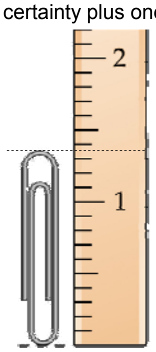
Section 2-3 Sig Figs

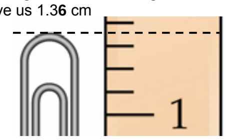
Significant Figures

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



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Section 2-3 Sig Figs

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**02.0**5 → 6 sig figs

Trailing Zeros – to the right of a decimal

Ex. 5.3**00** → 4 sig figs

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Section 2-3 Sig Figs

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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Section 2-3 Rounding

Rounding Sig Figs (Apply rules in order)

Look at the digit to the right…	**For 2 sig figs…**
1) If it is higher than 5 → round up	2.18 becomes 2.2
2) If it is lower than 5 → round down	2.13 becomes 2.1
3) If it is 5, and nonzeros come after → round up	2.151 becomes 2.2
4) If it is 5, and last sig fig is odd → round up	2.15 becomes 2.2
5) If it is 5, and last sig fig is even → round down	2.25 becomes 2.2

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Section 2-3 Math with Sig Figs

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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Section 2-3 Math 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 (2 8) Uncertain (0)

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Section 2-3 Math with Sig Figs

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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Section 2-3 Math 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 (2) Uncertain (7) Placeholder (0)

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Section 2-3 Math 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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Section 2-3 Scientific Notation

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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Section 2-3 Scientific Notation

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
→ 4.5×10^4

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
→ 3.4×10^{-3}

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Section 2-3 Scientific Notation

Addition and Subtraction with Scientific Notation

Exponents must match for addition.

4.5×10^4	45000
+ 2.3×10^4	+ 23000
6.8×10^4	68000

Exponents that do not match can be "fixed"

- Move the decimal one digit to the right to decrease the exponent by one (Number bigger – Exponent smaller)
- Move the decimal one digit to the left to decrease the exponent by one (Number smaller – Exponent bigger)

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Section 2-3 Scientific Notation

Addition and Subtraction with Scientific Notation

3.10×10^5
+ 2.30×10^4
Unmatched Exponents

Fix Exponents	Add	Compare
3.10×10^5	3.10×10^5	310000
+ 2.30×10^{4} (4 → 5)	+ 0.230×10^5	+ 23000
	3.33×10^5	333000

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Section 2-3 Scientific Notation

Multiplication and Division with Scientific Notation

Multiply the numbers, Add the exponents

3.1×10^5	310000
x 2.0×10^4	x 20000
$(3.1 \times 2.0) \times 10^{(5+4)}$	6200000000
6.2×10^9	

Divide the numbers, Subtract the bottom exponent

$$\frac{8 \times 10^5}{2 \times 10^3} = \frac{8}{2} \times 10^{(5-3)} = 4 \times 10^2 \qquad \frac{800000}{2000} = 400$$

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2-3 Using Scientific Measurement

Section 2-3 Scientific Notation

Rules for Calculations with Scientific Notation

Rule	Example
Addition and Subtraction All values must have the same exponent before they can be added or subtracted. The result is the sum or difference of the first factors all with the same exponent of 10.	$4.5 \times 10^6 - 2.3 \times 10^5 =$ $45 \times 10^5 - 2.3 \times 10^5$ $= 42.7 \times 10^5$ $= 4.3 \times 10^6$
Multiplication The first factors of the numbers are multiplied and the exponents of 10 are added.	$(3.1 \times 10^3)(5.01 \times 10^4) =$ $(3.1 \times 5.01) \times 10^{4+3}$ $= 16 \times 10^7 = 1.6 \times 10^8$
Division The first factors of the number are divided, and the exponent of 10 in the denominator is subtracted from the exponent of 10 in the numerator.	$\frac{7.63 \times 10^3}{8.6203 \times 10^4} = \frac{7.63 \times 10^{3-4}}{8.6203}$ $= 0.89 \times 10^{-1} = 8.9 \times 10^{-2}$

Section 2-3 Direct Proportion

Direct Proportion

Mathematically:

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

Effect:

If one variable increases, the other increases

If one variable decreases, the other decreases

Ex.

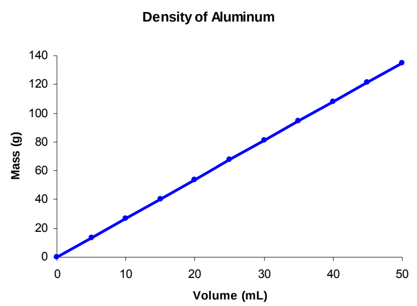
Freddy increased his study time to increase his grade.

When he studied very little, his grade was a low number.

Section 2-3 Direct Proportion

Direct Proportion example

As volume increases, mass increases.



Section 2-3 Inverse Proportion

Inverse Proportion

Mathematically:

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

$\propto$ 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

Section 2-3 Inverse Proportion

Inverse Proportion example

As speed increases, driving time decreases.