1.1 The scientific method
1.2 Units of measurement
1.3 Uncertainty in measurement – precision and accuracy
1.4 Significant figures and calculations
1.5 Dimensional analysis
1.4 SIGNIFICANT FIGURES AND CALCULATIONS
1.4

Significant figures and calculations

- All certain digits plus one estimated digit
**Significant Figures in Measurements**

- **Significant figures** in a measurement include all of the digits that are known, plus one more digit that is estimated.
- Measurements must be reported to the correct number of significant figures.
Any digit that is not zero is significant
- 2.234 kg 4 significant figures

Zeros between nonzero digits are significant
- 607 m 3 significant figures

Zeros to the left of the first nonzero digit are **not** significant
- 0.07 L 1 significant figure

If a number is greater than 1, then all zeros to the right of the decimal point are significant
- 5.0 mg 2 significant figures

If a number is less than 1, then only the zeros that are at the end and in the middle of the number are significant
- 0.00520 g 3 significant figures

You must be within 1 sig fig – it does not need to be perfect, but sig figs DO count!
Rules for Counting Significant Figures

Two special situations have an *unlimited* number of significant figures:

1. Counted items
   a) 23 people, or 425 thumbtacks

2. Exactly defined quantities
   b) 60 minutes = 1 hour
Sig Fig Practice #1

How many significant figures in the following?

1.0070 m → 5 sig figs
17.10 kg → 4 sig figs
100,890 L → 5 sig figs
3.29 x 10^3 s → 3 sig figs
0.0054 cm → 2 sig figs
3,200,000 mL → 2 sig figs
5 dogs → unlimited

These all come from some measurements
This is a counted value
How many significant figures are in each of the following measurements?

- 24 mL: 2 significant figures
- 3001 g: 4 significant figures
- 0.0320 m³: 3 significant figures
- $6.4 \times 10^4$ molecules: 2 significant figures
- 560 kg: 2 significant figures
Rounding Calculated Answers

- **Rounding**
  - Decide *how many* significant figures are needed
  - Round to that many digits, counting from the *left*
  - Is the next digit less than 5? Drop it.
  - Next digit 5 or greater? Increase by 1
  - 3.016 rounded to hundredths is 3.02
    - 3.013 rounded to hundredths is 3.01
    - 3.015 rounded to hundredths is 3.02
    - 3.045 rounded to hundredths is 3.04
    - 3.04501 rounded to hundredths is 3.05
Rounding Calculated Answers

- **Addition and Subtraction**
  - The answer should be rounded to the same number of decimal places as the least number of decimal places in the problem. Examples:

  \[
  \begin{array}{c}
  4.8 \\
  \hline
  - 3.965 \\
  \hline
  0.835 = 0.8
  \end{array}
  \]
Examples

Make the following have 3 sig figs:

- 761.50 → 762
- 14.334 → 14.3
- 10.44 → 10.4
- 10789 → 10800
- 8024.50 → 8020
- 203.514 → 204
Rounding Calculated Answers

- **Multiplication and Division**
  - Round the answer to the same number of **significant figures** as the **least** number of significant figures in the problem.

\[
34.6 \times 12.1 \times 1.2 = 502.392
\]

- last digit retained
- digits to be dropped
- least number of significant figures
- answer round to two significant figures

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1.4

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Rules for Significant Figures in Mathematical Operations

- **Multiplication and Division:** # sig figs in the result equals the number in the least precise measurement used in the calculation.

  \[
  6.38 \times 2.0 = 12.76 \rightarrow 13 \text{ (2 sig figs)}
  \]

  Three significant figures

  \[
  \frac{278 \text{ mi}}{11.70 \text{ gal}} = 23.8 \text{ mi/gal}
  \]

  Four significant figures

Three significant figures

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Significant Figures in Calculations

- In general a calculated answer cannot be more precise than the *least precise* measurement from which it was calculated.
- Ever heard that a chain is only as strong as the weakest link?
- Sometimes, calculated values need to be *rounded off*. 
### Sig Fig Practice #2

<table>
<thead>
<tr>
<th>Calculation</th>
<th>Calculator says:</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.24 m x 7.0 m</td>
<td>22.68 m²</td>
<td>23 m²</td>
</tr>
<tr>
<td>100.0 g ÷ 23.7 cm³</td>
<td>4.219409283 g/cm³</td>
<td>4.22 g/cm³</td>
</tr>
<tr>
<td>0.02 cm x 2.371 cm</td>
<td>0.04742 cm²</td>
<td>0.05 cm²</td>
</tr>
<tr>
<td>710 m ÷ 3.0 s</td>
<td>236.66666667 m/s</td>
<td>240 m/s</td>
</tr>
<tr>
<td>1818.2 lb x 3.23 ft</td>
<td>5872.786 lb·ft</td>
<td>5870 lb·ft</td>
</tr>
<tr>
<td>1.030 g ÷ 2.87 mL</td>
<td>2.9561 g/mL</td>
<td>2.96 g/mL</td>
</tr>
</tbody>
</table>
Rules for Significant Figures in Mathematical Operations

• **Addition and Subtraction**: The number of decimal places in the result equals the number of decimal places in the least precise measurement.

\[
6.8 + 11.934 = 18.734 \rightarrow 18.7 \text{ (3 sig figs)}
\]

\[
89.332 + 1.1 \quad \text{one significant figure after decimal point}
\]

90.432 \quad \text{round off to 90.4}

\[
-2.9133 - 0.7867 \quad \text{two significant figures after decimal point}
\]

0.7867 \quad \text{round off to 0.79}
## Sig Fig Practice #3

<table>
<thead>
<tr>
<th>Calculation</th>
<th>Calculator says:</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.24 m + 7.0 m</td>
<td>10.24 m</td>
<td>10.2 m</td>
</tr>
<tr>
<td>100.0 g - 23.73 g</td>
<td>76.27 g</td>
<td>76.3 g</td>
</tr>
<tr>
<td>0.02 cm + 2.371 cm</td>
<td>2.391 cm</td>
<td>2.39 cm</td>
</tr>
<tr>
<td>713.1 L - 3.872 L</td>
<td>709.228 L</td>
<td>709.2 L</td>
</tr>
<tr>
<td>1818.2 lb + 3.37 lb</td>
<td>1821.57 lb</td>
<td>1821.6 lb</td>
</tr>
<tr>
<td>2.030 mL - 1.870 mL</td>
<td>0.16 mL</td>
<td>0.160 mL</td>
</tr>
</tbody>
</table>

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