Scientific Notation
Significant Figures
Scientific Notation

- A shorthand method of displaying very large (distance to the sun) or very small numbers (lengths of atoms).
- Consists of a coefficient, a base 10, and an exponent
- e.g. \( 3.95 \times 10^3 \)
- The coefficient must be between 1 and 10 or it is not in scientific notation.
- If the exponent is positive (such as above), the number will be large (greater than 1).
- If the exponent is negative, the number will be small (less than 1).

First Press the 2nd function key

Second Press The EE key
Express in Scientific Notation

- E.g. $3756 = ?$
- $3756 = 3.756 \times 10^3$
- $0.000493 = ?$
- $0.000493 = 4.93 \times 10^{-4}$
Express in Standard Notation

• E.g. \( 5.21 \times 10^4 = \)
  The exponent is positive, so make the coefficient a large number (move the decimal to the right)
  \( 5.21 \times 10^4 = 52100 \)

• \( 2.694 \times 10^{-5} \)
  The exponent is negative, so make the coefficient a small number (move decimal to the left).
  \( 2.694 \times 10^{-5} = 0.00002694 \)
Practice

• Put in scientific notation
  • 1. 8720000 =
  • 2. 0.0000513 =
  • 3. 5302 =
  • 4. 0.00117 =

• Put in standard notation
  • 5. 7.03 x 10^{-2} =
  • 6. 1.38 x 10^{4} =
  • 7. 3.99 x 10^{-5} =
  • 8. 2.781 x 10^{7} =
Practice - Answers

1. $8720000 = 8.72 \times 10^6$
2. $0.0000513 = 5.13 \times 10^{-5}$
3. $5302 = 5.302 \times 10^3$
4. $0.00117 = 1.17 \times 10^{-3}$
5. $7.03 \times 10^{-2} = 0.0703$
6. $1.38 \times 10^4 = 13800$
7. $3.99 \times 10^{-5} = 0.0000399$
8. $2.781 \times 10^7 = 27810000$
Write as Correct Scientific Notation

• 1. $34.79 \times 10^3 = $

• 2. $0.497 \times 10^6 = $

• 3. $19.5 \times 10^{-2} = $

• 4. $0.837 \times 10^{-4} = $
Write as Correct Scientific Notation - Answers

• 1. $34.79 \times 10^3 = 3.479 \times 10^4$

• 2. $0.497 \times 10^6 = 4.97 \times 10^5$

• 3. $19.5 \times 10^{-2} = 1.95 \times 10^{-1}$

• 4. $0.837 \times 10^{-4} = 8.37 \times 10^{-5}$
And then Al realized his problems were much bigger than just a smashed truck.
Significant Figures

• When counting objects we can find an exact number
  – eg numbers of students in class
• When measuring quantities there is usually some amount of uncertainty in the number
  – eg length of classroom, mass of person
• We need to have an idea of which digits are meaningful and which are not
How long is each line?

In Figure 1, the line is 1.6cm, therefore 2 s.f.
In Figure 2, the line is 1.63cm (or 1.62 or 1.64), so 3 s.f.

The number of sig figs consists of certain digits + one uncertain (educated guess) digit.

The precision of the measuring device determines the number of sig figs. Fig. 2 has a higher precision A measurement of 1.635725cm for either ruler would be nonsense.
A significant figure (or significant digit) is a measured or meaningful digit.

Significant figures (or “Sig fig’s”) are the digits known to be exact plus one more that may have some uncertainty but is an educated guess.

The following examples show how many digits can be determined in different cases.
• On the centimetre ruler above we know the length at the arrow is between 2 cm and 3 cm
• If the smaller divisions are 0.1 cm we know the length is between 2.8 cm and 2.9 cm
• We can’t read another digit, but we can estimate how many tenths of a division past 2.8 to the arrow
• We can estimate 2 tenths of a division which gives a measurement of 2.82 cm
• We state the measurement as 2.82 cm.
• We are certain about the first 2 digits and have some certainty about the third
  • eg - we know the third digit is not 0 or 9, (but it might be 1 or 3)
• This measurement has 3 sig figs
• We cannot give the measurement of 2.8275 because we cannot be that exact with this ruler
• More than 12, less than 13
• More than 12.3, less than 12.4
• Estimated length = 12.33 cm
  (4 significant figures)
• Note it could also be estimated as 12.32 cm or 12.34 cm - be as accurate as you can
• Any of these last 3 would be an acceptable measurement
Length is between 4 and 5 cm. Arrow is right at the 0.5 cm mark.

Our guess digit will be a 0 as the measurement is right on the line.

Length can be reported as 4.50 cm. If you can be certain about adding a zero, DO IT!

We know it is not 4.48 cm or 4.53 cm, but it could be 4.51 cm - some uncertainty (but probably not!)
How many degrees Celsius?

- Decide what each marked division represents
- Estimate between marked divisions
- Estimated temperature
  - Between 21 and 22 degrees C
  - Best estimate 21.8 degrees C
  - 3 sig figs
Graduated Cylinder

- Estimated volume is between 20 and 30 mL (read at bottom of meniscus curve)
- Large division is 5 mL, each small one is 1 mL
- Estimate between 27 and 28 mL
- Volume = 27.5 mL
- 3 sig figs
Graduated Cylinder

- Large division is 0.5 mL, each small one is 0.1 mL
- Volume is 5 ml, but we know it more precisely. We can read 5.0 using marked divisions and estimate one more decimal place
- Volume = 5.00 mL (3 sig figs)
Rules for Significant Figures

• **A)** all non zero digits are significant

• **B)** zero’s are significant if:
  – They are at at the end of a number if decimal point is shown. i.e. 2.50 (3 sig figs)
  – They are enclosed by non-zero numbers. i.e. 2002 (4 sig figs)

• **C)** zeros that hold place value only are not significant. i.e. 100 (1 sig fig)

• OR zeros leading off a number
Examples

• 34.500
• 5 significant figures
• 0.0087
• 2 significant figures
• 3507
• 4 significant figures
• 1500
• 2 significant figures
Trailing Zeros Exception

- 61000   2 sig figs (zeros are not significant)
- What if you want 100 to have three sig figs?
- Use scientific notation…$1.00 \times 10^2$
- Sig figs for scientific notation:
- The number of digits in the coefficient **IS** the number of sig figs!
Same number
Different Sig. Figs.

- 1200
- 1200.0
- $1.2 \times 10^3$
- $1.20 \times 10^3$
- $1.200 \times 10^3$
Same number
Different Sig. Figs.

- 1200  2 sig figs (zeros not significant)
- 1200.0  5 sig figs
- (Note 1200. Is not legal usage - if decimal is written a digit must follow it)
- $1.2 \times 10^3$  2 sig figs
- $1.20 \times 10^2$  3 sig figs
Perfect Numbers

- Counting numbers or defined values are considered to be exact or perfect numbers and are exempt from rules of sig. figs.
Practice - How many Sig Figs

- 13.0 mm
- 48.07 g
- 0.050 cm
- 1001 L
- 5 students
- 15000 g
- 1 L = 1000 mL
- $3.00 \times 10^{-3}$
Practice - How many Sig Figs

- 13.0 mm                  3 sig figs
- 48.07 g                  4 sig figs
- 0.050cm                  2 sig figs
- 1001 L                   4 sig figs
- 5 students               perfect number
- 15000 g                  2 sig figs
- 1 L = 1000 mL            perfect number
- 3.00 x 10^{-3}           3 sig figs
Scientists devise yet another way of delaying death.