The Measure of Science

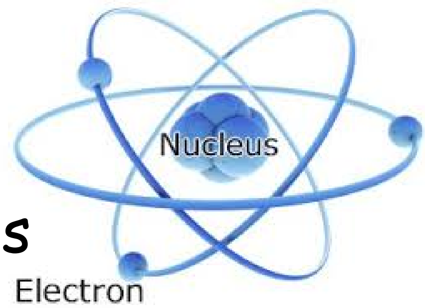
In this course we will be using the metric system.

Common units include the second (s), meter (m), and kilogram (kg).

Scienctific Notation

Scientists often work with very large or very small numbers.

For example, the mass of the Earth is about
6 000 000 000 000 000 000 000 000 kg



While the mass of an electron is
0.000 000 000 000 000 000 000 000 000 000 911 kg

These are long numbers to write down whenever you need them.

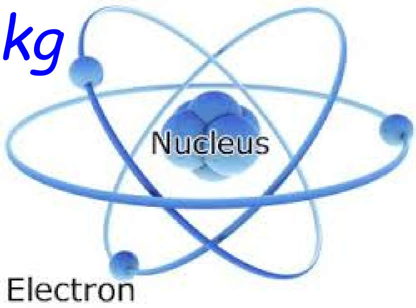
Using scientific notation, we can take these long numbers and write them in a more compact way to say the same thing.

We could write the mass of the Earth as

6×10^{24} kg

Or the mass of the electron as

9.11×10^{-31} kg



In general, numbers can be written in scientific notation by using the following expression.

$$M \times 10^{n}$$

Where $1 \leq M < 10$ and n is an integer

For example, a 180g softball could be written as 1.8×10^{2}g (What would this look like in kilograms?)

Write the following measurements in scientific notation.

25 800 000 000 kg

4562 mm

149 600 000 000 m

0.00000000547 L

0.000812 s

5 970 000 000 000 000 000 000 000 kg

152.006 J

0.00000000000000000000000001673 kg

Prefixes used with SI Units

The number system is a decimal system. *Prefixes* are used to change SI units by powers of 10.

Metric System

Prefix	Symbol	Power	Example (***meter)	Long Notation (meter)	Scientific Notation (meter)
tera	T	10^{12}	1 Tm =	1 000 000 000 000 m	1×10^{12} m
giga	G	10^{9}	1 Gm =	1 000 000 000 m	1×10^{9} m
mega	M	10^{6}	1 Mm =	1 000 000 m	1×10^{6} m
kilo	k	10^{3}	1 km =	1 000 m	1×10^{3} m
hecto	h	10^{2}	1 hm =	100 m	1×10^{2} m
deca	da	10^{1}	1 dam =	10 m	1×10^{1} m
		10^{0}	1 m =	1 m	1×10^{0} m
deci	d	10^{-1}	1 dm =	0.1 m	1×10^{-1} m
centi	c	10^{-2}	1 cm =	0.01 m	1×10^{-2} m
milli	m	10^{-3}	1 mm =	0.001 m	1×10^{-3} m
micro	µ	10^{-6}	1 µm =	0.000 001 m	1×10^{-6} m
nano	n	10^{-9}	1 nm =	0.000 000 001 m	1×10^{-9} m
pico	p	10^{-12}	1 pm =	0.000 000 000 001 m	1×10^{-12} m
femto	f	10^{-15}	1 fm =	0.000 000 000 000 001 m	1×10^{-15} m
atto	a	10^{-18}	1 am =	0.000 000 000 000 000 001 m	1×10^{-18} m

As long as we know the power rules for multiplying and dividing powers then we can convert between common (and uncommon) prefixes.

Metric System Examples

Convert the following into units provided

a. 2567 m = ____________ km

b. 45.6mm = _____________ cm

c. 0.0435 nm = ___________ dm

d. 5.481 hm = _____________ Gm

e. 69.45 Mm = ___________ mm

f. 8561.4 cm = _____________ µm

g. 0.004387 Tm = __________ dam

h. 721.56 dm = _____________ mm

i. 54.3 pm = ____________ m

j. 24.5 km = ________________ cm

k. 3.56mm = ____________ pm

l. 257 cm = _________________ Mm

m. 1 784 581 125 µm = __________ km

n. 0.000000673 dm = _____________ nm

So, in short …………….

Converting from a smaller unit to a larger unit, the decimal place is shifted to the _________________!

Converting from a larger unit to a smaller unit, the decimal place is shifted to the _________________!

Converting units using the metric system.........examples

2567 m = 2.567 km

0.0435 nm = 0.0000000000435 dm

69.45 Mm = 69 450 000 000 mm

0.004387 Tm = 438 700 000 dam

54.3 pm = 0.0000000000543 m

3.56 mm = 3 560 000 000 pm

1 784 581 125 µm = 1.784581125 km

45.6 mm = 4.56 cm

5.481 hm = 0.0000005481 Gm

8561.4 cm = 85 614 000 µm

721.56 dm = 72 156 mm

24.5 km = 2 450 000 cm

257 cm = 0.00000257 Mm

0.000000673 dm = 67.3 nm

So, in short...............

Converting from a <u>smaller</u> unit to a <u>larger</u> unit, the decimal place is shifted to the left!

Converting from a <u>larger</u> unit to a <u>smaller</u> unit, the decimal point is shifted to the right!

Convert each of the following to the indicated unit: (you may then write answer in scientific notation afterwards)

85.3 mm = ________________________ km
7 834 000 000 000 nm = ______________________ m
5874 Gm = _________________________ dam
0.00056 Tm = _________________________ cm
8542 μm = ___________________________ hm
7.23 Mm = ____________________________ pm
26.3 dm = _____________________________ km
65.9 cm = _____________________________ nm
8965 Gm = ____________________________ μm
1.56 pm = ______________________________ cm

Convert each of the following to the indicated unit: (you may then write answer in scientific notation afterwards)

85.3 mm = 0.0000853 km — 8.53×10^{-5} km

7 834 000 000 000 nm = 7834 m — 7.834×10^{3} m

5874 Gm = 587 400 000 000 dam — 5.874×10^{11} dam

0.00056 Tm = 56 000 000 000 cm — 5.6×10^{10} cm

8542 μm = 0.00008542 hm — 8.542×10^{-5} hm

7.23 Mm = 7 230 000 000 000 000 000 pm — 7.23×10^{18} pm

26.3 dm = 0.00263 km — 2.63×10^{-3} km

65.9 cm = 659 000 000 nm — 6.59×10^{8} nm

8965 Gm = 8 965 000 000 000 000 000 μm — 8.965×10^{18} um

1.56 pm = 0.000000000156 cm — 1.56×10^{-10} cm

Operations with Scientific Notation

When adding or subtracting quantities expressed in scientific notation, the quantities must be expressed with the same power of 10^x to do so.

i.e.) $(8.67 \times 10^6) + (3.2 \times 10^6) = 11.9 \times 10^6 \longrightarrow 1.19 \times 10^7$

$(4.23 \times 10^5) - (1.5 \times 10^4) =$

needs to be the same power

Operations with Scientific Notation

When multiplying or dividing quantities expressed in scientific notation, the quantities may be expressed with different powers of 10^x.

$(7.45 \times 10^6) \times (8.256 \times 10^3) = 61.5 \times 10^9 \longrightarrow 6.15 \times 10^{10}$

$(9.7608 \times 10^{-9}) \div (4.621 \times 10^4) = 2.112 \times 10^{-13}$

Try the following

a) $(4 \times 10^{8}\ m) + (3 \times 10^{8}\ m) =$

b) $(6.2 \times 10^{-3}\ m) - (2.8 \times 10^{-3}\ m) =$

c) $(4.0 \times 10^{6}\ m) + (3 \times 10^{5}\ m) =$

d) $(4.0 \times 10^{-6}\ kg) - (3 \times 10^{-7}\ kg) =$

e) 4.1 m + 1.5468 km =

f) $(2.31 \times 10^{-2}\ g)$ + 6.1 mg =

g) $(3 \times 10^{6}\ m)(2 \times 10^{3}\ m) =$

h) $(2 \times 10^{-5}\ m)(4 \times 10^{9}\ m) =$

i) $(4 \times 10^{3}\ kg)(5 \times 10^{11}\ m) =$

j) $\dfrac{8 \times 10^{6}\ m}{2 \times 10^{3}\ s} =$

k) $\dfrac{8 \times 10^{6}\ kg}{2 \times 10^{-2}\ s} =$

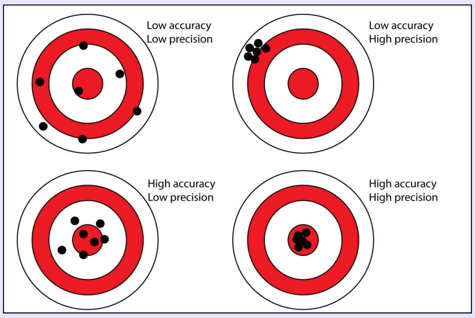
Part 1 Worksheet

The Measure of Science - Part 2

There are many mathematical calculations performed when measuring physical properties and scientists around the world use a set of rules to indicate the degree of accuracy and precision of these measurements. All measurements are subject to uncertainty.

Precision - is the degree of exactness to which a measurement can be reproduced.

Accuracy - describes how well the result agrees with an accepted value.

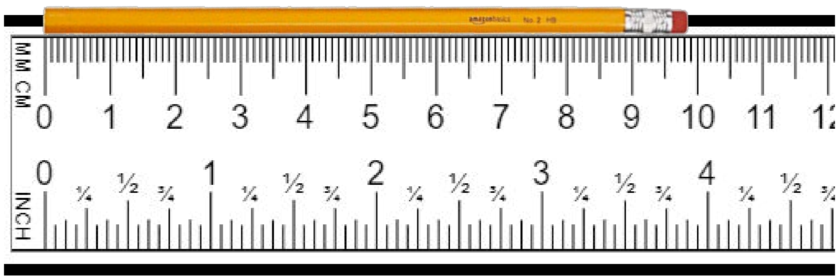


https://www.vox.com/science-and-health/2018/11/14/18072368/kilogram-kibble-redefine-weight-science

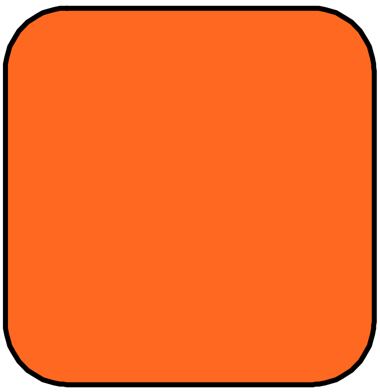
What are significant figures??

- the number of digits in a measurement we know **<u>for certain</u>** *plus one additional uncertain digit.*

For example...



What would you report the length of the object to be??



If it were zoomed in, does that change your answer?

What other measuring devices can you think of where significant figures would apply? What about some that won't?

Significant figures have specific rules that we follow:

- include all non-zero digits. (2.59 - three sig fig)
- include any zeros between two non-zero digits (507 - three sig fig)
- include any zeros to the right of both the decimal point and a non-zero digit. (4.60 - three sig fig) or (700.0 - four sig fig)
- include all digits (zero or non-zero) used in scientific notation

Digits that are NOT significant include....

- any zeros to the right of a decimal point but preceding a non-zero digit. (0.000045 g - two sig dig)
- any zeros to the right of a non-zero digit. (38 000 - two sig dig)

Lets try a few… guess how many significant figures each number has.

425.6 m
1.05 km
9.6093 kg
5.0 g
6 lbs
0.5 hr
600 g
600.0 g
0.24 m
0.006
0.0245
0.42
0.00560
173.2×10^{-3} M

Need some extra practice? Try these!

3.0×10^{8} m/s (speed of light) 0.7 s 9.7 ounces

15 000 000 L 6.7523 km 3.45 m

0.0000410 kg 9.109×10^{-31} kg (mass of an electron)

0.08905 L 4.501 hm 440 µm 4.0 cm

6.02×10^{23} amu (Avogadro's number) 0.00465 km 0.454g

Try it here: https://quizlet.com/_673j0h

Rounding

- if the number after the digit to be kept as significant is a 5 or greater, - round UP.
- if the nuber after the digit to be retained as significant is a 4 or less, - round DOWN. (leave digit as is)

Important - Never round a value too early when more calculations need to be done. It will give you an incorrect answer.

Adding and Subtracting Significant Figures

- when adding and subtracting significant figures, the answer (sum or difference) has the same number of place values as the measured value with fewest place value.

i.e.)

12.45 cm + 4.2 cm = 16.65 cm
report answer as: =

3.26 km + 5.4698 km = 8.7298 km
report answer as: =

7.8521 L + 0.032 L = 7.8841 L
report answer as: =

Multiplying and Dividing Significant Figures

- when multiplying and/or dividing significant figures, the answer has the same number of significant figures as the measurement with the fewest number of significant figures.

i.e)

6.71 m × 7.850 m = 52.6735 m^2
report answer as: =

2.4 cm × 0.08 cm = 0.192 cm^2
report answer as: =

0.4251 L × 39.7525 L = 16.89878785 L^2
report answer as: =

44.794 g ÷ 19.13 cm = 2.341557762676.... g/cm
report answer as: =

Calculating Significant Figures with Multi-Step Problems

Use order of operations and keep track of your significant figures throughout the problem.

Example: Solve with the proper number of significant figures.

$$\frac{1.07 - 0.8826}{0.762}$$

$$\frac{82.7}{0.18} + 114.25$$

Rearranging Formulas

Hints to rearrange formulas:

1. Eliminate any fractions
2. Add/subtract any terms to the other side of the equals sign that do not contain the variable
3. Divide by any coefficients in front of the variable
4. Take the root of any power on the variable

<u>Examples</u>

Solve the following equation for x

$$\frac{ay}{x} = \frac{cb}{s}$$

Solve the following equation for x

$$y = mx + b$$

$$v_f^2 = v_i^2 + 2ad \qquad \text{for } v_i$$

Measure of Science Worksheet - Part 2