8.45 kg to μg

$kg = 10^{3}\,g$ $\qquad$ $\mu g = 10^{-6}\,g$

$$8.45\,\cancel{k}g \times \frac{10^{3}\,\cancel{g}}{\cancel{kg}} \times \frac{\mu g}{10^{-6}\,\cancel{g}} = \boxed{\begin{array}{c} 8450000000\,\mu g \\ 8.45 \times 10^{9}\,\mu g \end{array}}$$

88100 kHz to MHz

$kHz = 10^{3}\,Hz$

$MHz = 10^{6}\,Hz$

$\boxed{Hz: s^{-1}\ (\text{frequency})}$

$$88100\,\cancel{kHz} \times \frac{10^{3}\,Hz}{\cancel{kHz}} \times \frac{MHz}{10^{6}\,Hz} = \boxed{88.1\ MHz}$$

Convert 38.47 in to m, assuming 2.54 cm = 1 in

$2.54\ cm = in \qquad cm = 10^{-2}\ m$

$$38.47\ \cancel{in} \times \frac{2.54\ \cancel{cm}}{\cancel{in}} \times \frac{10^{-2}\ m}{\cancel{cm}} = \boxed{0.9771\ m}$$

Convert 12.48 km to in

$2.54\ cm = in \qquad cm = 10^{-2}\ m \qquad Km = 10^{3}\ m$

$$12.48\ \cancel{Km} \times \frac{10^{3}\ \cancel{m}}{\cancel{Km}} \times \frac{\cancel{cm}}{10^{-2}\ \cancel{m}} \times \frac{in}{2.54\ \cancel{cm}} = \boxed{\begin{array}{c} 491300\ in \\ 4.913 \times 10^{5}\ in \end{array}}$$

Accuracy and Precision

- two related concepts that you must understand when working with measured numbers!

Accuracy

- how close a measured number is to the CORRECT (or "true") value of what you are measuring

- "Is it right?"

- checked by comparing measurements against a STANDARD (a substance or object with known properties)

Precision

- how close a SET of measured numbers are to EACH OTHER

- "Can I reproduce this?"

- checked by repeated measurements

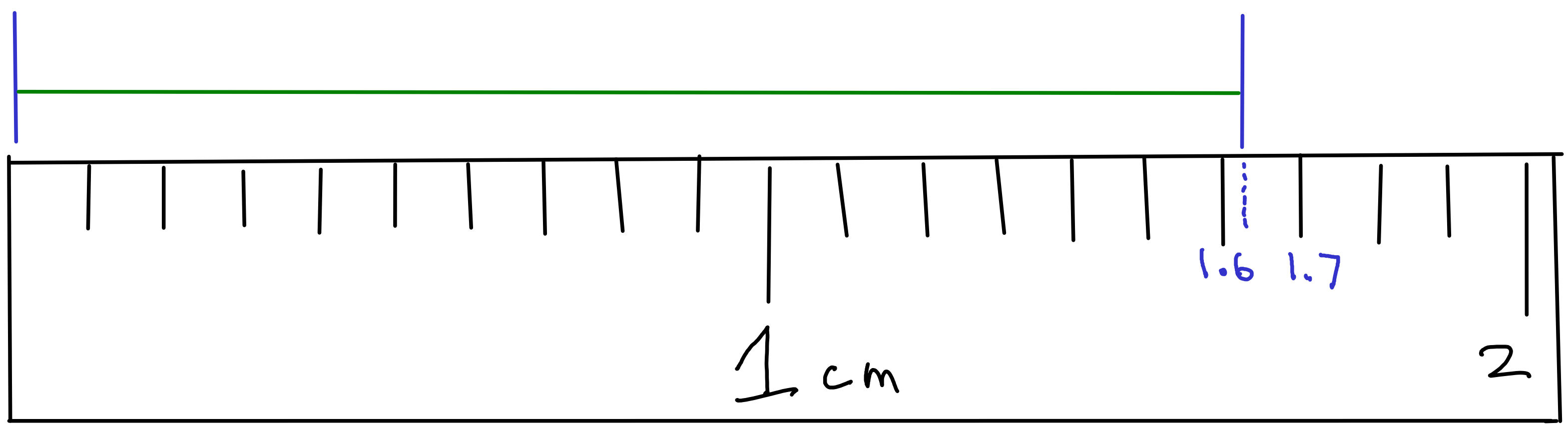
More on precison

Every measurement contains some amount of ERROR, or some amount of deviation from the true value of what is being measured.

RANDOM ERROR is the variability in a measurement that cannot be traced back to a single cause. Random errors cause measurements to fluctuate around the true value, but can be averaged out given enough measurements.

When reporting measurements, we want to indicate how much random error we think is present. How?

Form: X.XX cm



How long is the green line?

Write your answer on the card, then pass the card up to the front!

Our classroom experiment: Results

After throwing away obvious mistakes in reading the scale, we had:

Value	# students
1.60	1
1.62	15
1.63	24
1.64	2

42 measurements

Overall average

$\bar{x} = 1.626190476$ cm (unrounded)

$= \underbrace{1.6}\underbrace{3} \pm 0.01$ cm

CERTAIN DIGITS: Appear in nearly all repeats of the measurement

UNCERTAIN DIGITS: Vary.. Variation caused by estimation or other sources of random error.

When reading measurements from a scale, record all CERTAIN digits and one UNCERTAIN (or estimated) digit.

Significant figures

SIGNIFICANT FIGURES are a way to indicate the amount of uncertainty in a measurement.

The significant figures in a measurement are all of the CERTAIN DIGITS plus one and only one UNCERTAIN (or estimated) DIGIT

Example:

From our classroom experiment,

1.63 cm

We estimated the last digit, It's uncertain

These digits were obtained in all measurements. They are certain

THIS MEASUREMENT HAS "THREE SIGNIFICANT FIGURES"!

Determining significant figures

When you read a measurement that someone has written using the significant figures convention, you can tell how precisely that measurement was made.

1.473 g ± 0.001

This was measured to the nearest +/- 0.001 g
The last digit is always UNCERTAIN (or estimated)

21 m ± 1

37.26 kg ± 0.01

Some other examples

3.2076 g ± 0.0001 g

uncertain digits!

27.3 m ± 0.1 m

A small problem

The number ZERO has several uses. It may be a measured number, but it may also be a mere "placeholder" that wasn't measured at all!

So how do we tell a measured zero from a placeholder? There are a few ways:

1: BEGINNING ZEROS: Beginning zeros are NEVER considered significant.

$\underbrace{0}.\boxed{15}$ g

.15 g

This zero merely indicates that there is a decimal point coming up!

$\underbrace{0.0}\boxed{15}$ m (1.5 cm)

These zeros are placeholders. They'll disappear if you change the UNITS of this number!

$\underbrace{0.000}\boxed{63}$ mm

None of these zeros are considered significant

2: END ZEROS are sometimes considered significant. They are significant if

- there is a WRITTEN decimal point in the number
- there is another written indicator that the zero is significant. Usually this is a line drawn over or under the last zero that is significant!

$\boxed{1.50}$ km $\pm$ 0.01 km

This zero IS considered significant. There's a written decimal.

$\boxed{15}00$ m $\pm$ 100 m

These zeros ARE NOT considered significant (no written decimal, and no other indication that the zeros are significant)

$\boxed{143\bar{0}}00$ g $\pm$ 100 g

These zeros are not significant.

This zero IS significant. It's marked.