Metric Prefixes and Conversions

Prefixes for Powers of Ten

PREFIX	SYMBOL	NOTATION
tera	T	10^{12}
giga	G	10^{9}
mega	M	10^{6}
kilo	k	10^{3}
deci	d	10^{-1}
centi	c	10^{-2}
milli	m	10^{-3}
micro	µ	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}

1. Convert 45.20 centimeters into meters.

Factor-Label Method for Converting Units

a) Write factors so units cancel leaving desired units.

b) Write "1" next to each prefixed unit.

c) Write the power of 10 (i.e.- the exponent) with each base unit.

2. Convert 1.9 A into microamps.

3. Convert 0.0340 pm into kilometers.

$$.0340\,pm\left(\frac{10^{-12}\,m}{1\,pm}\right)\left(\frac{1\,km}{10^{3}\,m}\right) = .0340\times10^{-15}\,km$$

$$3.40\times10^{-17}\,km$$

4. Convert 12.8 cm² into m².

$$12.8\,cm^2\left(\frac{10^{-2}\,m}{1\,cm}\right)\left(\frac{10^{-2}\,m}{1\,cm}\right) = 1.28\times10^{-3}\,m^2$$

5. Convert 4700 kg/m³ into g/cm³

$$4700\,\frac{kg}{m^3}\left(\frac{10^{3}\,g}{1\,kg}\right)\left(\frac{10^{-2}\,m}{1\,cm}\right)\left(\frac{10^{-2}\,m}{1\,cm}\right)\left(\frac{10^{-2}\,m}{1\,cm}\right) = 4.7\,\frac{g}{cm^3}$$

6. Convert 55 mph into m/s. (1.0 mile ≈ 1.6 km)

7. Convert 700 seconds into nanoseconds.

7×10^{11} ns

8. Convert 2.40 gigabytes into bytes.

2.40×10^{9} bytes

9. Convert 10.25 Mℓ into mℓ.

1.025×10^{10} mℓ

10. Convert 45.0 m^3 into mm^3.

4.50×10^{10} mm^3

11. Convert 92.3 kg/cm^3 into g/m^3.

9.23×10^{10} g/m^3

12. Convert 30. m/s in to mph.

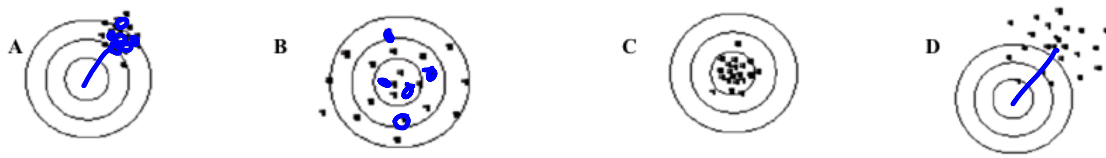
67 mph

Accuracy and Precision

Accuracy: An indication of how close a measurement is to the accepted value (a measure of correctness)

Precision: An indication of the agreement among a number of measurements made in the same way (a measure of exactness)

Rate the following groupings of shots on their accuracy and precision:



Systematic Error: An error associated with a particular instrument or experimental technique that causes the measured value to be off by a consistent, predictable amount each time.

Random Uncertainty: An uncertainty produced by unknown and unpredictable variations in the experimental situation whereby the recorded measurement has an equal probability of being above or below the true value.

1) Which target(s) above represents measurements made with significant systematic error?
A. D
2) Which target(s) above represent measurements made with significant random uncertainty?
B. D
3) Which type of uncertainty affects the accuracy of results?
systematic errors
4) Which type of uncertainty affects the precision of results?
random uncertainty
5) Which type of uncertainty can be eliminated from an experiment?
systematic errors
6) Which type of uncertainty can be reduced in an experiment but never eliminated?
random uncertainty
7) State a general method for reducing random uncertainty.
multiple measurements
8) Repeated measurements can make your answer more precise but not more accurate
9) An accurate experiment has low systematic errors
10) A precise experiment has low random uncertainty

Measurements and Uncertainties

No measurement is ever perfectly **exact** or perfectly **correct**. Every measurement has a degree of uncertainty associated with it.

1. If possible, record as many significant figures as the calibration of the measuring instrument allows **plus** one estimated digit.
2. Record a reasonable uncertainty estimate with one sig fig that matches the measurement in place value (decimal place).

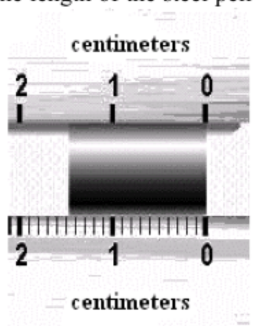
Record a measurement for the length of the steel pellet as measured by each ruler.

Top ruler:

1.4 cm ± 0.1 cm

Range of values:

1.3 cm - 1.5 cm



Bottom ruler:

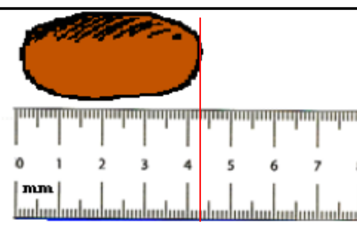
1.47 cm ± 0.02 cm

Range of values:

1.45 cm – 1.49 cm

What if the object doesn't have a sharp edge to measure from?

Limit precision to 1st estimated digit

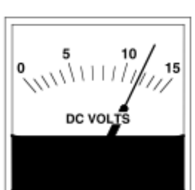


Measurement: 4.4 cm ± 0.2 cm

Record each measurement with an appropriate uncertainty:

1. Analog readings:

best judgement



11.7v ± .2v

4.5 kg ± .2 kg

2. Digital readings:

± 1 of smallest place

115.2 g ± .1 g

3. Stopwatch:

24.2~~6~~ s ± .3 s

24.3 ± .3 s

Single Trials and Multiple Trials

Task: measure the time for a ball to drop

Your measurement: Class measurements:

1.80s 1.95s 1.57s 1.92s
1.56s 1.65s 2.01s 1.93s
1.65s 1.48s 1.58s 1.26s

1. What are some reasons for the variations in answers?

1.26s — 2.01s

parallax - uncertainty in measurement due to perspective of person reading instrument

2. Reporting a measurement using a **single trial**: Your value: 1.7 s ± .3 s

Value: 1.65s

Uncertainty: .3s

Image

Rules for uncertainties:

a) Uncertainty should have only one significant figure. *

b) Uncertainty should match the measurement in precision (place value, number of decimal places).

3. Reporting a measurement using **multiple trials**: Class value: 1.7s ± .4s

Value: 1.697s → 1.7s

Range: 1.26s – 2.01s

Uncertainty: ± ½ range

± ½(2.01s - 1.26s)

± .375s → ±.4s

7

Data Processing

1. Averaging multiple trials:

The following measurements were made for the height of the classroom door. (What's wrong with the data table?)

Trial	Height (m) ±.002m
1	2.152
2	2.200
3	2.180
4	2.213

What final value should be reported?

mean: 2.18625 m → 2.19m

±½ range: $\pm \frac{(2.213m - 2.152m)}{2}$ = ±.0305m → ±.03m

2. Measuring several cycles:

A mass bounced up and down 5 times in 7.63 seconds as measured on a stopwatch.

How should the total time be recorded? 7.6 s ± .3 s

How much time did one full bounce take? (7.6 s ± .3 s)/5   1.52 s ± .06 s

3. Mathematical operations: calculate +/- 1/2 range

+ or - : add uncert

a) To find the volume of an irregular object by water displacement, the following data were taken. How should the volume of the object be reported?

Volume of water in graduated cylinder: 22.5 ml ± 0.1 ml

Volume of water plus object: 83.7 ml ± 0.1 ml

Volume of object:

83.7 ml − 22.5 ml = 61.2 ml

± ½ range

± ½ (61.4 ml − 61.0 ml) = ± .2 ml

Determining uncertainty:

Maximum volume:

83.8 ml − 22.4 ml

= 61.4 ml

Minimum volume:

83.6 ml − 22.6 ml

= 61.0 ml

x or / : add uncert as %

b) To find the area of his desktop, a student took the following data. How should the area be reported?

Length of desktop: 38.4 cm ± 0.3 cm $\frac{.3}{38.4} \sim .8\%$

Width of desktop: 72.9 cm ± 0.3 cm $\frac{.3}{72.9} \sim .4\%$

Area of desktop:

38.4cm × 72.9cm = 2799.36 cm²

±1.2%

±30cm²

±½ range = ±33cm²

2800 cm² ± 30 cm²

Determining uncertainty:

Maximum area:

38.7cm × 73.2cm

2833... cm²

Minimum area:

38.1cm × 72.6cm

2766cm²

c) To find the speed of a toy car, the following data were taken. How should the speed be reported?

Distance traveled: 4.23 m ± 0.05 m

Time taken: 8.7 s ± 0.2 s

Speed:

Determining uncertainty:

Maximum speed:

Im

Minimum speed: