Measurment & Uncertainty

Measurement = Value & unit

↑ The #

↑ what type of measurement

Units are the System of measurement

	English	System International (SI)
		Base unit & prefix
Length	Ft, in, yards	meter
Mass	lbs, oz	Kilogram
Volume	gal, quarts, floz	Liter
Time	sec, min, hr	second

Prefix

Giga	G	$\times 10^{9}$
mega	M	$\times 10^{6}$
Kilo	k	$\times 10^{3}$
Base		
Centi	c	$\times 10^{-2}$
Milli	m	$\times 10^{-3}$
micro	μ	$\times 10^{-6}$
nano	n	$\times 10^{-9}$

$1{,}273\ \text{kg} = ?\ \text{g}$

k = $\times 10^3$

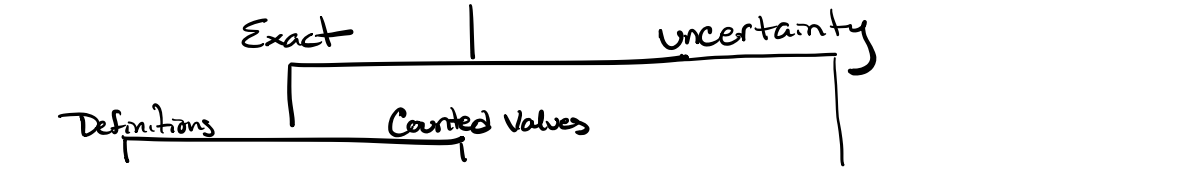
$1{,}273 \times 10^3\ \text{g}$

$6.23\ \mu\text{g} = ?\ \text{g}$

$\mu = \times 10^{-6}$

$6.23 \times 10^{-6}\ \text{g}$

Types of Values (numbers)



A value that is set by definition

Ex

Exactly 12 in = 1 ft

Exactly 2.54 cm = 1 in

1000 g = 1 kg

Items that are not divisible

Ex

6 pen

12 Shoes

6 atoms

~~32 lbs~~

~~102 seconds~~ } measured not Counted

Measured Quantities

Values that are obtained through measurement using some sort of measuring device

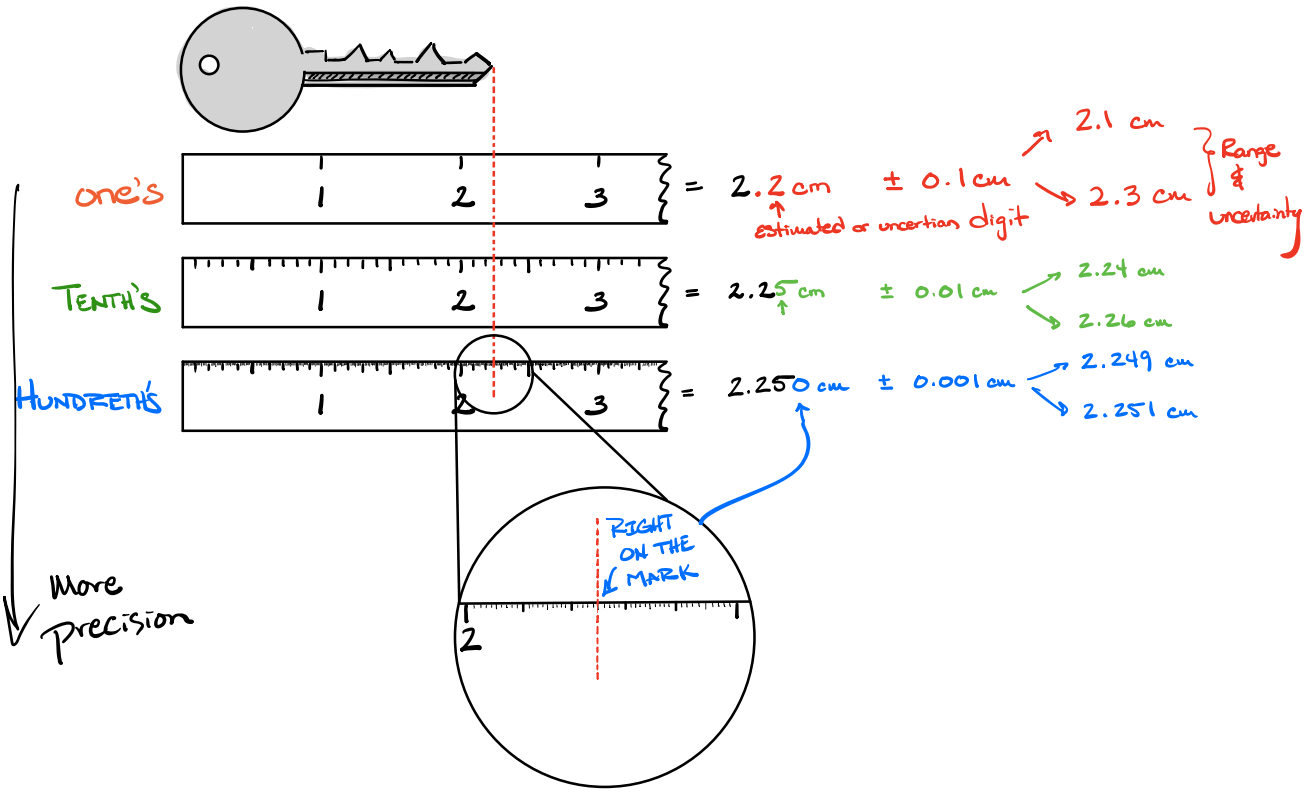
± uncertainty

32 lbs ± 1 lbs

32.67 lbs ± 0.01 lbs

102 sec ± 1 sec

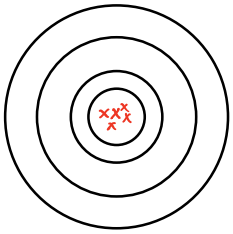
102.37 sec ± 0.01 sec



The more precise = Less uncertainty

Precision ⇒ Degree of uncertainty

Accuracy ⇒ How close the value is to the true value.
Factor of Calibration of the measuring device.

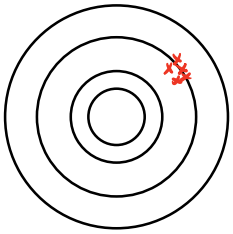


Accurate

All measurements close to true value

Precise

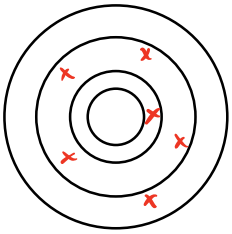
All measurements close together small ±



not Accurate

but very precise

Example of good ruler but poorly calibrated

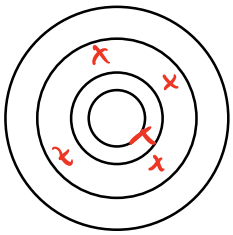


not Accurate

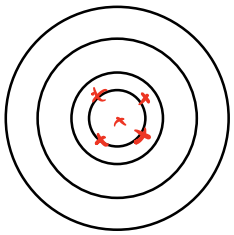
&

not precise

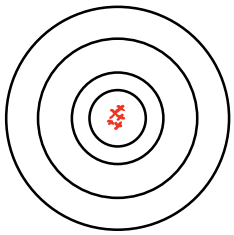
Ruler Example w/ key from above



± 0.1 cm



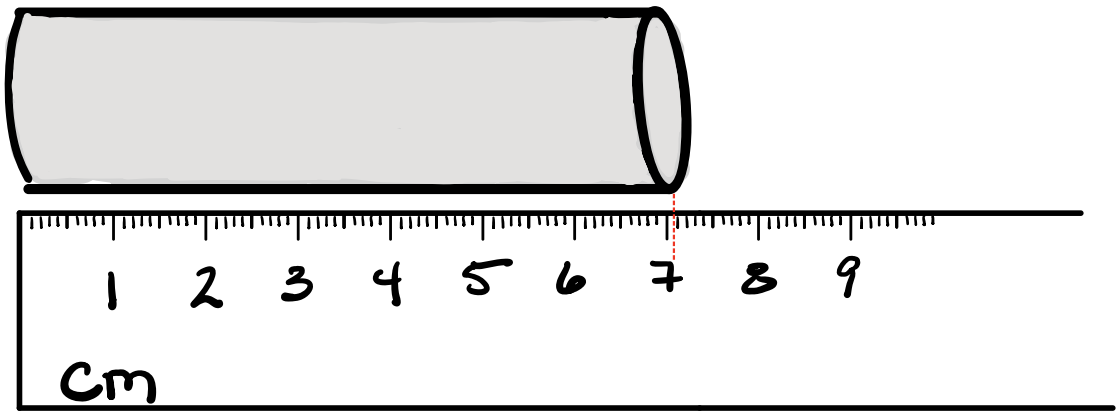
± 0.01 cm



± 0.001 cm

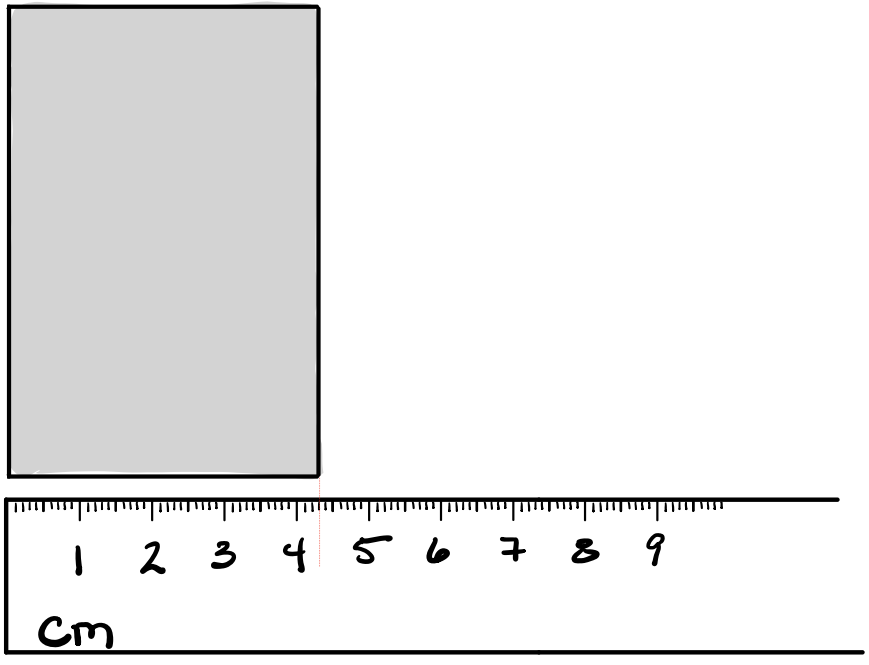
Increasing precision

Increasing Uncertainty

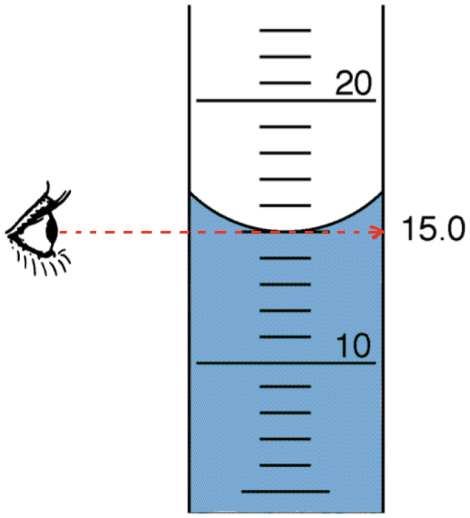


Ruler is marked in 1/10's so estimate to 1/100's position

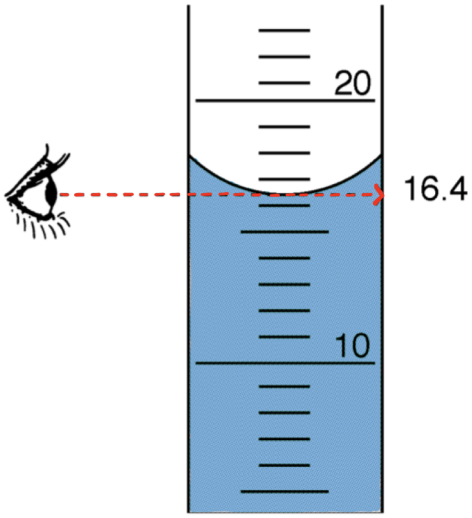
7.07 cm or 7.08 cm



4.31 cm or 4.30 cm both correct

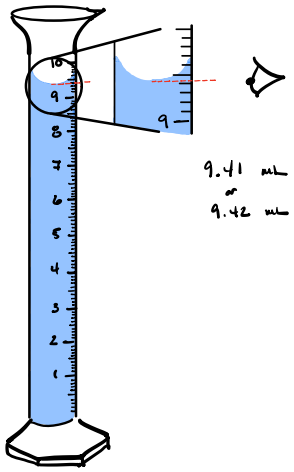


(a)

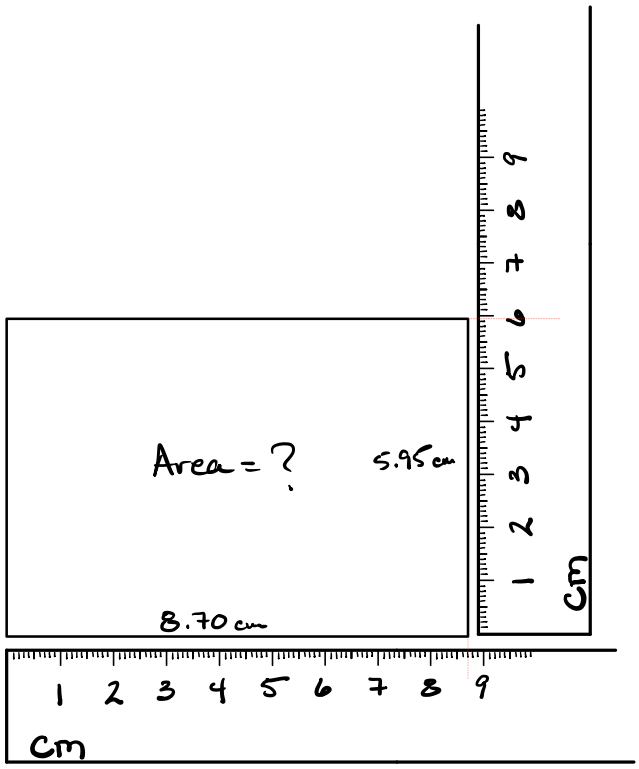


(b)

Graduated Cylinder

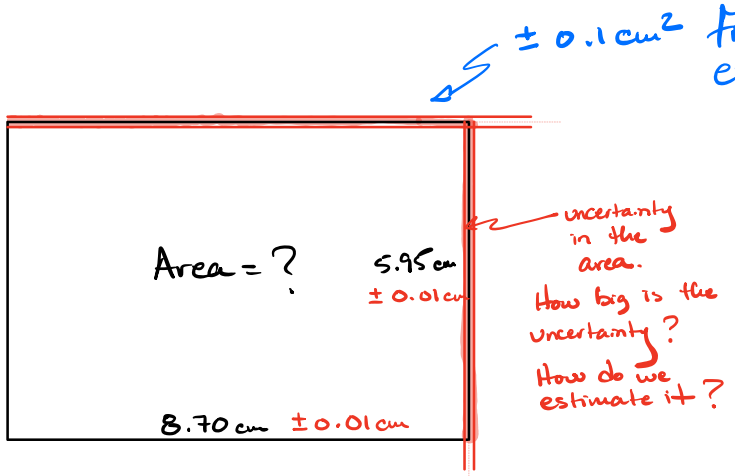


Milliliters



$$\text{Area} = \ell \times w$$

$$\text{Area} = 8.70\,\text{cm} \times 5.95\,\text{cm}$$
$$= 51.765\,\text{cm}^2$$



$$5.95\,\text{cm} \times 8.70\,\text{cm} = 51.765\,\text{cm}^2$$

$$(5.95\,\text{cm} \pm 0.01\,\text{cm}) \times (8.70\,\text{cm} \pm 0.01\,\text{cm}) = 51.765\,\text{cm}^2 \pm ?$$

Need a system for estimating uncertainty

$\Rightarrow$ Significant figures

Significant figures (Significant Digits)

is a system for estimating uncertainty in a calculation.

$5.95\ cm \times 8.70\ cm = 51.765\ cm^2$

3 SF × 3 SF = 3 SF

$= 51.8\ cm^2 \pm 0.1\ cm^2$

Significant Figure Rules

12,010 ft	Large
1.0079 sec	~ 1
.0000079 cm	Small

Zero's can be part of measurement (Significant) or Zero's can be placeholders for the value (not Significant)

① All non-zero digits are Significant

	Sig figs
1.6273	5
19.21	4
13.7	3
5672	4

② Any zero flanked by non-zero's is part of the measurement and is Significant.

	Sig figs
10.72	4
1603.02	6
10001.9	6

③ Any zero to the right of the decimal and to the right of non-zero digits is Significant.

	Sig figs
92.700 ft	5
132.9210 sec	7
8.70 cm	3

④ Zero's to the right of the decimal, but to the left of the 1st non-zero digit are placeholder for values less than 1 ⇒ not Significant.

	Sig figs
$0.0125\ mL = 1.25 \times 10^{-2}\ mL$	3
$0.00063942\ L = 6.3942 \times 10^{-4}\ L$	5
$0.00193\ m = 1.93 \times 10^{-3}\ m$	3

(5) Zero's to the right of the last non-zero digit and to the left of the decimal may or may not be Significant.

2100 m
93,710 cm
1,290,000 gal
} poorly expressed

$2100.$ = 4 Sig figs
↑ planted

2100 = 2 Sig figs
placeholders

2100 cm = 2.100×10^3 cm — 4 SF

= 2.10×10^3 cm — 3 SF

= 2.1×10^3 cm — 2 SF

Use Scientific Notation to Communicate SF

Decimal Form Requires all 5 rules for SF
Scientific Notation ⇒ all digits Significant

Sig Figs

0.0092 cm (placeholders)	2 SF	9.2×10^{-3} cm
73.650 mL (↑ trailing zero after decimal)	5 SF	7.3650×10^{1} mL
1200 gal (no decimal; trailing before decimal)	2 SF	1.2×10^{3} gal
1.6920 L (↑ trailing)	5 SF	1.6920×10^{0} L
3.2000×10^{2} sec	5 SF	