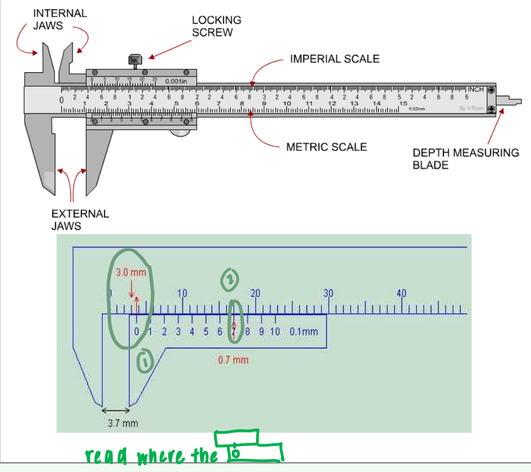
MEASUREMENT

Accuracy: how close a measurement is to its **true value**
Precision: How close a measurement is to **one another**

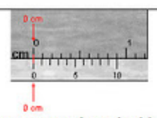
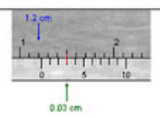
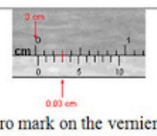
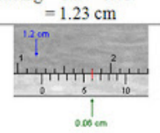
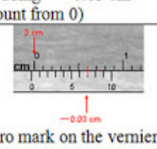
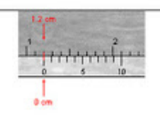
Percentage error:
The difference between the experimental result and the true value

$$percentage\ error = \frac{|theoretical\ value - experimental\ value|}{theoretical\ value}(100\%)$$

Measuring lengths

	Meter ruler & tape measure	Vernier caliper How to Read a Metric Vernier Caliper	Micrometer Screw Gauge
Purpose		Often used to measure the external/internal diameter of an object	
Precision	0.1 cm	0.01 cm	0.001 cm
Image			

read where the 0 hits

Checking for zero error	Observed reading	Actual reading = observed reading – zero error
 Two zero marks coincide => No zero error	 Reading = 1.2 + 0.03 = 1.23 cm	1.23 cm as no zero error correction required.
 Zero mark on the vernier scale is slightly to the right of the zero mark on the main scale => positive zero error Reading = + 0.03 cm (count from 0)	 Reading = 1.2 + 0.06 = 1.26 cm	1.26 – (+0.03) = 1.23 cm
 Zero mark on the vernier scale is slightly to the left of the zero mark on the main scale => negative zero error Reading = - 0.03 cm (count from 10).	 Reading = 1.20 cm	1.20 – (- 0.03) = 1.23 cm

SI units

Physical quantities
- Quantities that can be measured

Based quantities
- Base Quantities: lead to a complete description of physics in the simplest terms
- Based on international agreement by scientists

Derived quantities
- Obtained from 1 or more base quantities through a defining equation
- All these quantities have an SI unit (International System)

SI Base units: simplest form

Length	m	metre
Mass	kg	kilogram
Time	s	second
Electric current	A	ampere
Temperature	K	kelvin
Amount of substance	mol	mole

SI derived units: made of SI base units

Derived Quantities	Defining Equation	Base SI Units	Derived unit
Volume	$Vol = l^3$	m^3	-
Velocity	$v = d/t$	ms^{-1}	-
Force	$F = ma$	$kgms^{-2}$	N
Moment	$F \times d$	kgm^2s^{-2}	Nm
Energy	$E = mg\Delta h$ or $E = \frac{1}{2}mv^2$	kgm^2s^{-2}	J

Standard Index form: $1<x<10 \times 10^n$

Prefix	Symbol	Sub-multiple
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. Instruments where reading is recorded to the smallest division.

Instruments	Smallest division/ precision	Examples of readings
metre rule	0.1cm/ 0.001m	29.9cm, 30.0cm, 30.1cm 0.299m, 0.300m, 0.301m
half-metre rule		
measuring tape		
vernier calipers	0.01cm	3.21cm, 3.22cm, 3.23cm
micrometer screw gauge	0.01mm	4.56mm, 4.57mm, 4.58mm
protractor	1°	2°, 57°, 90°
digital stopwatch	0.01s	9.87s, 9.88s, 9.99s
electronic balance	0.01g	1.74g, 1.75g, 1.76g

highlighted in yellow = super common

2. Instruments where reading is recorded to half of the smallest division.

Instruments	smallest division	precision	examples of readings
thermometer	1°C	0.5°C	29.0°C, 29.5°C, 30.0°C
ammeter (0-1A)	0.02A	0.01A	0.25A, 0.26A, 0.27A
voltmeter (0-1V)	0.02V	0.01V	0.25V, 0.26V, 0.27V
measuring cylinder ($100cm^3$)	$1cm^3$	$0.5cm^3$	$18.0cm^3$, $18.5cm^3$, $19.0cm^3$
spring balance (0-10N)	0.1N	0.05N	6.05N, 6.10N, 6.15N