Measurements

Base Quantities and Units

Mass	Length	Time	Current	Temperature	Amount of Substance	Luminous Intensity
kg	m	s	A	K	mol	cd

Homogeneity of Physical Equations

- Expressions separated by "+", "–" and "=" have the same units

$s = ut + \frac{1}{2}at^2$

$[s] = [ut] = [at^2]$

Half is a numerical constant with no units

But not all constants are unitless. g = 9.81 m s^{-2} is a constant with units

$F.s = \frac{1}{2}mv^2$

$[Fs] = [mv^2]$

$[F] = \frac{[m][v][v]}{[s]}$

$[F] = \frac{kg.ms^{-1}.ms^{-1}}{m} = kg\ m\ s^{-2}$

kg m s^{-2} is the SI base unit of force while N is the SI unit.

Prefixes

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

Uncertainty and Derived Uncertainty

Addition and Subtraction	Multiplication and Division
• $c = ma \pm nb$ (m and n are constants) ○ $\Delta c = m\Delta a + n\Delta b$, ALSO: ○ $\Delta a = \frac{1}{m}\Delta c + \frac{n}{m}\Delta b$ *, and ○ $\Delta b = \frac{1}{n}\Delta a + \frac{m}{n}\Delta c$ *	• $c = \frac{ma^x b^y}{d^z}$ (m,x,y and z are constants) ○ $\frac{\Delta c}{c} = x\frac{\Delta a}{a} + y\frac{\Delta b}{b} + z\frac{\Delta d}{d}$

Note:

- *a, b, c* and *d* are independent from one another.
  1. If not, use the maximum and minimum value,

$$\Delta c = \frac{c_{max} - c_{min}}{2}$$

- *Make the derived quantity the subject first before applying the rule

Errors / Uncertainties

Absolute	Fractional	Percentage
Δc	$\frac{\Delta c}{c}$	$\frac{\Delta c}{c} \times 100\%$

Random Error

A random error is an error which gives a **scatter** of readings about an **average value.** It has an **equal chance** of being **positive or negative** and can be **reduced by averaging**.

Systematic Error

A systematic error is a **constant deviation** of readings **from the true value** in **one direction**. **All measurements will be too high or too low by the same amount**. It can be **reduced by correct laboratory practice**.

Precision (of an instrument):	a term used to describe the level of uncertainty in an instrument's scale. High precision instruments have small scale divisions.
Accuracy (of an instrument):	is the closeness of a reading on an instrument to the true value of the quantity being measured. An accurate instrument will give readings close to the true values.
Precision (of a set of readings):	is the degree of closeness of the readings with one another. It is associated with small random error.
Accuracy (of a set of readings):	is the degree of closeness of the average value of the readings to the true value. It is associated with small systematic error.

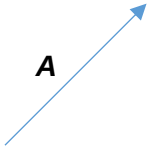
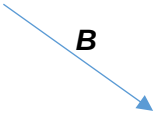
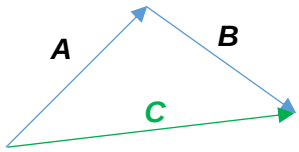
Vectors

- Have directions and magnitudes
- Therefore, when we say there is a change in a vector, it could mean
    1. Magnitude change only; or
    2. Direction change only; or
    3. Both magnitude and direction change
- "Change" in a quantity means how *different* is the final quantity from the initial quantity. Therefore in mathematical equation, for example, a change in velocity means

$$\Delta v = v_{final} - v_{initial}$$

    1. The equation above is a vector equation. Refer to above bullet points on what does a "change" means. See below on evaluating a change in vector.
    2. To evaluate a vector equation, drawing the vectors and use geometry to determine both magnitude and direction of the final vector.

Vectors Manipulation

Vector *A*	Vector *B*	*C* = *A* + *B*
		
		C = *A* – *B*