

Units of measurement



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Imperial vs Metric

Metric	Imperial
• Based on 7 base units • Uses a decimal system (*10) making it easier to scale • Consistent, logical and used worldwide • Required in engineering and science	• Uses inches, feet, pounds, gallons • No consistent pattern (12in = 1ft, 3ft = 1 yard, 16 oz = 1lb) • Still used in some industries and countries • Prone to mistakes when converting

Système International d'Unités

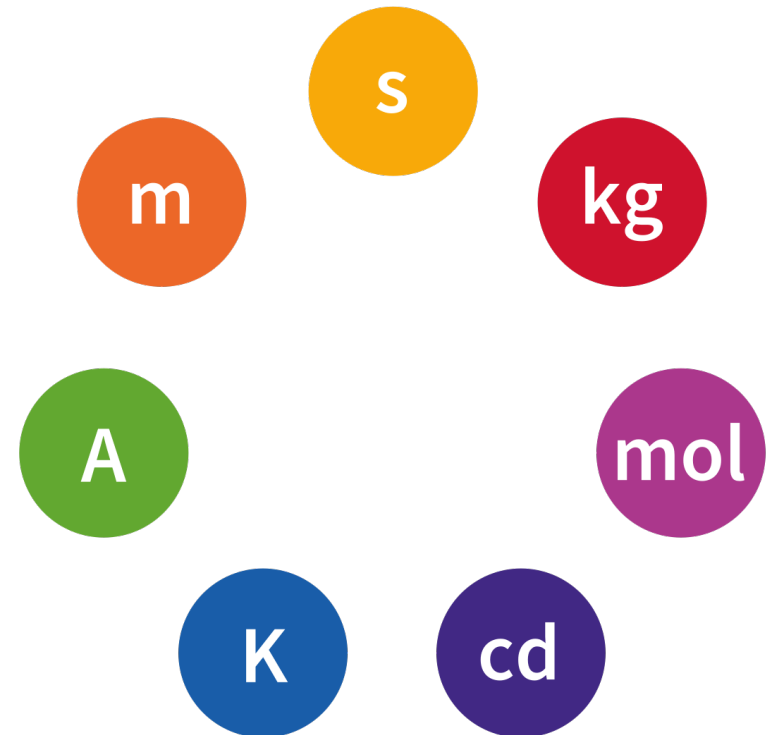
- The modern metric system is entirely based around SI units
- These units were internationally agreed in 1960 at the **General Conference on Weights and Measures (CGPM)** however they had been developed since the 1800s
- They provide a single standard set of units that all humans can use worldwide
- They built it around 7 base units



*Members of the 10th CGPM
which developed early steps
towards CGPM*

Base SI Units

- There are 7 “base” units in engineering and science
- All other units are built from these base units
- They are the “building blocks” of derived units



Base SI Units - Time

- Time is measured in **seconds**
- These have the units s
- The duration of 9,192,631,770 oscillations of radiation from the caesium-133 atom.
- Used to be based on $1/86400$ of a mean solar day but due to uneven rotation of the earth it was changed to be something more predictable



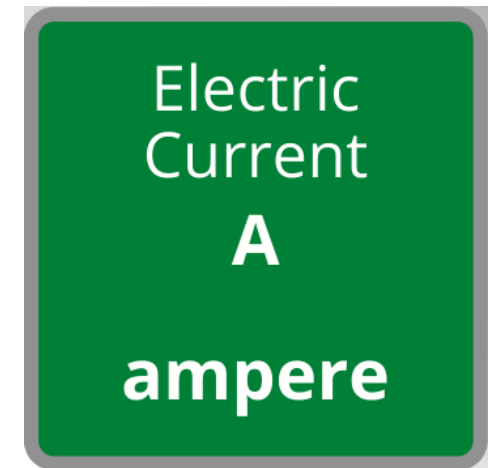
Base SI Units - Mass

- Mass is measured in **kilograms**
- These have the units **kg**
- Based on the Planck constant “h” which is $6.62607015 * 10^{-34}$
- The Planck constant (h) is just a really, really tiny number that tells us how much energy is in one “packet” of light (a photon) for each wave of it.



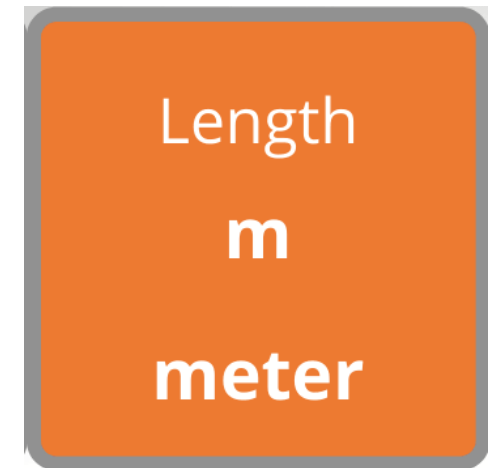
Base SI Units – Electric Current

- Electric Current is measured in **ampere**
- These have the units **A**
- Defined via the elementary charge $e = 1.602176634 * 10^{-19}$
- The elementary charge (symbol e) is the smallest unit of electric charge that exists in nature.
- (1 proton = $+e$) (1 electron = $-e$)



Base SI Units – Length

- Length is measured in **metres**
- These have the units **m**
- Distance light travels in vacuum in $\frac{1}{299,792,458}$ of a second
- This value is based on the speed of light as $c=299,792,458\text{m/s}$

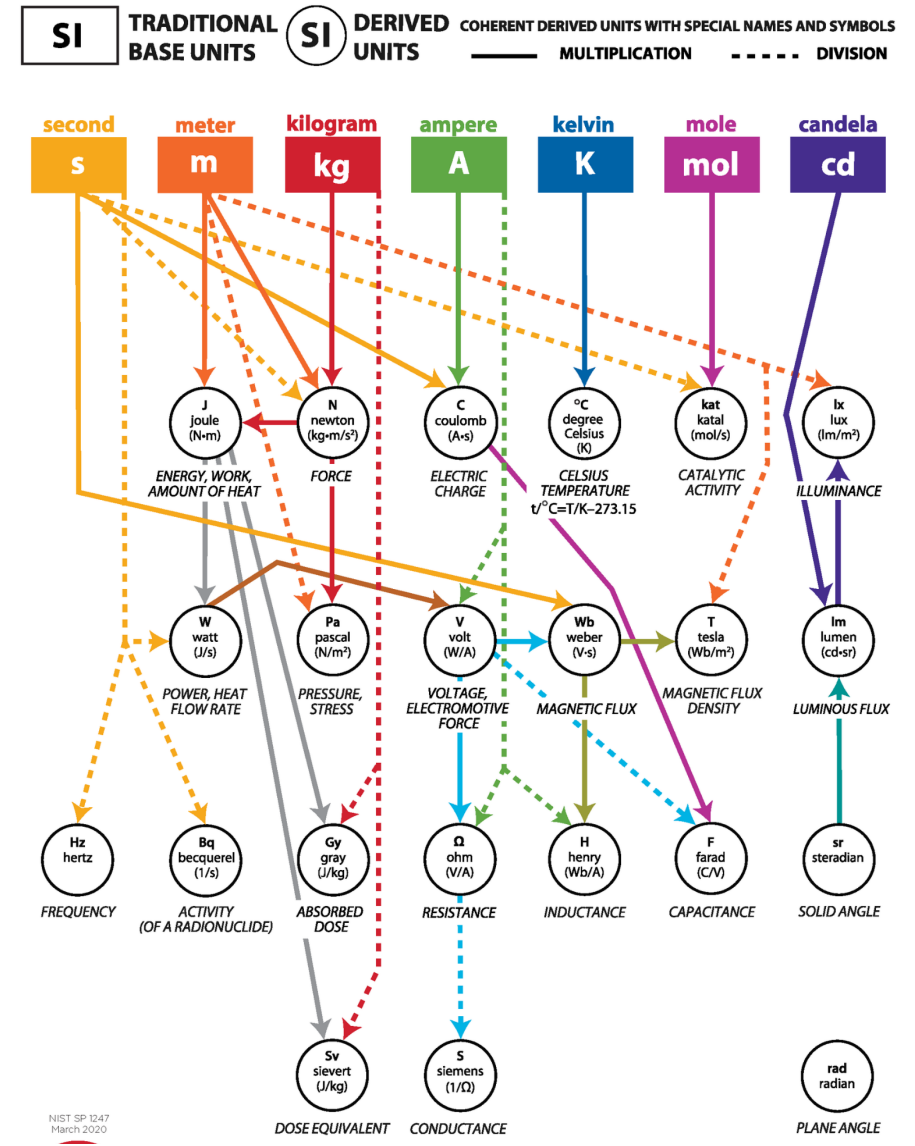


SI Units you don't have to know

- Your specification says you don't have to know these but it's helpful to know
- Base SI unit for temperature -> Kelvin
- Base SI unit for light intensity -> Candela
- Base SI unit for amount of substance -> Mole

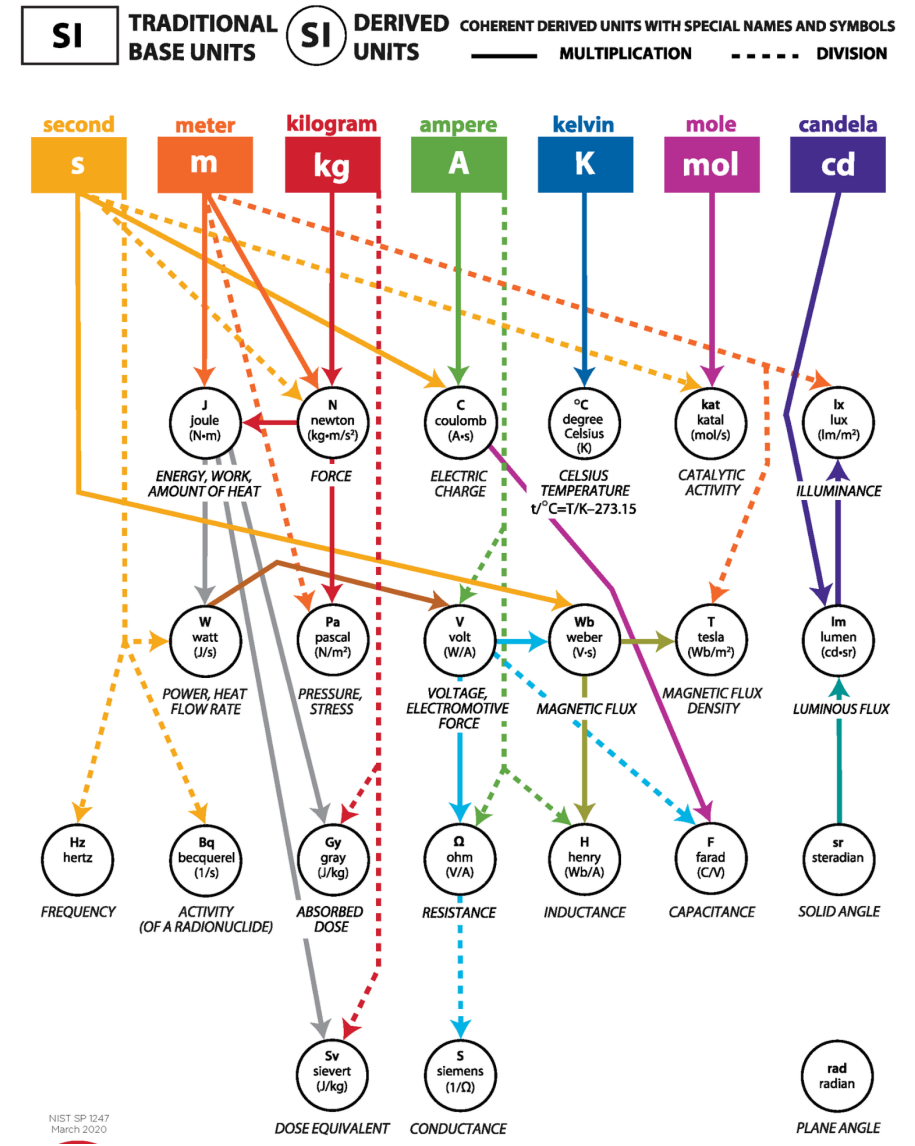
Derived SI Units

- A derived unit measures more complex values
- They are “constructed” out of the base SI Units
- They can always be written in their “base form”



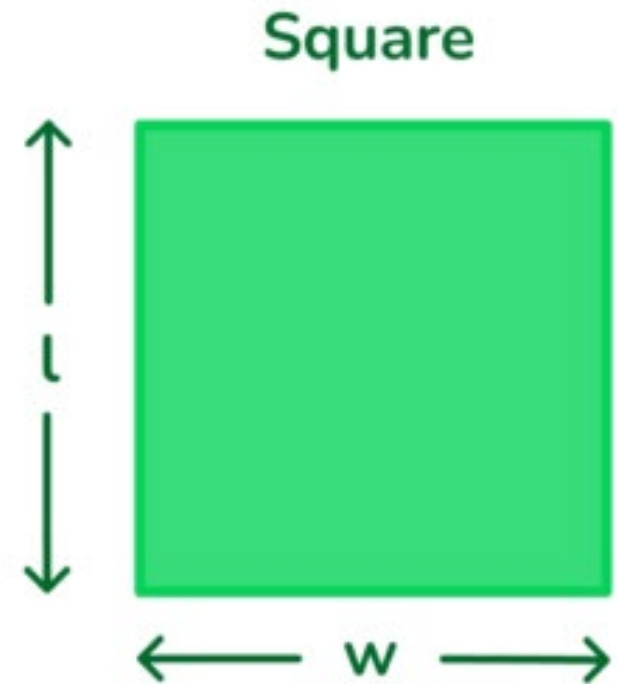
Derived SI Units

- A derived unit measures more complex values
- They are “constructed” out of the base SI Units
- They can always be written in their “base form”
- They always contain at least two base units



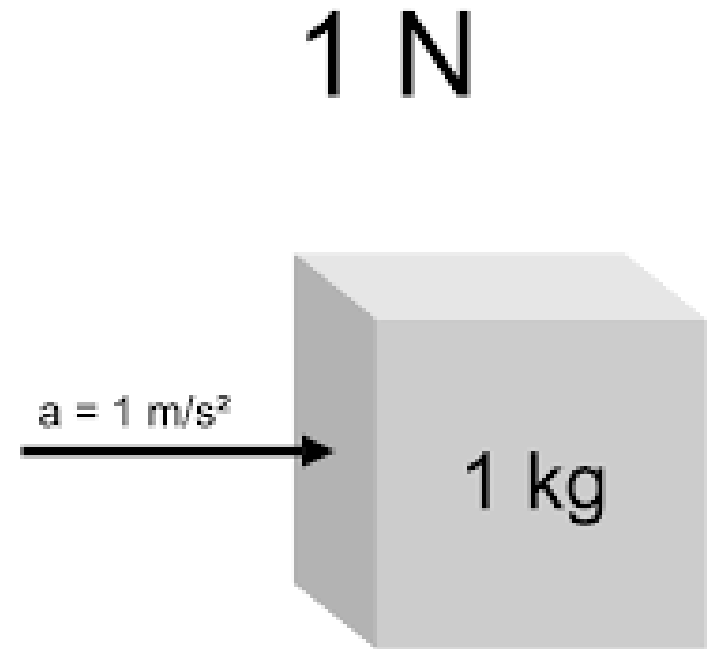
Derived SI Units - Area

- One of the simplest derived units is **area**
- Area has the symbol **m^2**
- This means it is made from the base units **$m * m$** which is **length * length**



Derived SI Units - Force

- Another derived unit is **newtons**
- Force has the symbol **N**
- However, in base units Force is defined as $kg * m/s^2$



Unit multiples and submultiples

- Engineering and science often deals with **very large or very small numbers**
- SI units use **prefixes** to make numbers easier to read and work with
- All these prefixes are **powers of 10** which makes them easy to use
- These prefixes come from across Europe including Latin, Greek and modern made-up words

Submult	Prefix	Char	Mult	Prefix	Char
10^{-1}	deci	d	10	deca	da
10^{-2}	centi	c	10^2	hecto	h
10^{-3}	milli	m	10^3	kilo	k
10^{-6}	micro	u	10^6	mega	M
10^{-9}	nano	n	10^9	giga	G
10^{-12}	pico	p	10^{12}	tera	T
10^{-15}	femto	f	10^{15}	peta	P
10^{-18}	atto	a	10^{18}	exa	E
10^{-21}	zepto	z	10^{21}	zetta	Z
10^{-24}	yocto	y	10^{24}	yotta	Y

All prefixes

Submult	Prefix	Char	Mult	Prefix	Char
10^{-1}	deci	d	10	deca	da
10^{-2}	centi	c	10^2	hecto	h
10^{-3}	milli	m	10^3	kilo	k
10^{-6}	micro	u	10^6	mega	M
10^{-9}	nano	n	10^9	giga	G
10^{-12}	pico	p	10^{12}	tera	T
10^{-15}	femto	f	10^{15}	peta	P
10^{-18}	atto	a	10^{18}	exa	E
10^{-21}	zepto	z	10^{21}	zetta	Z
10^{-24}	yocto	y	10^{24}	yotta	Y

Converting engineering units

- If we have a value like 10km we can convert that to base units
- To do that we multiply by the multiple
- $10km = 10 * 10^3 = 10 * 1000 = 10,000m$
- The same is true if we have a submultiple
- $10mm = 10 * 10^{-3} = 10 * 0.001 = 0.01m$