Physical Quantities

Physical attributes that are measurable are known as **Physical Quantities**. A physical quantity always consists of a numerical **magnitude** and a **unit**.

Examples of Physical Quantities

200 km
12.3 dB
23 Hz
47.3 °C
300 kN

Accuracy of Measurement

Accuracy refers to the closeness of a measured value to a standard or known value.

Precision

Precision refers to the closeness of two or more measurements to each other.

Random Errors

It occurs in all measurements.
It occurs whenever an observer estimates the last figure of a reading on an instrument.
Causes:
- human reaction time
- background noise
- mechanical vibrations

It cannot be predicted.
It can be reduced by taking large numbers of readings and averaging them.

Systematic Errors

It is not random but constant.
It may cause an observer to consistently underestimate or overestimate a reading.
Causes:
- zero error of an instrument: any indication that a measuring system gives a false reading when the true value of a measured quantity is zero

It can be eliminated if we know the sources of the errors.

Taking Measurements

Different measuring instruments are used for measuring different quantities. The choice of instrument will affect the precision of the measurement we obtain.
The precision of an instrument is usually equal to the smallest division of the instrument with a few exceptions such as the thermometer, ammeter and voltmeter.

SI Units and Base Quantities

The *International System of Units* is the modern form of the metric system, and is the most widely used system of measurement.
It is comprised of a system of units built on seven **base units**.

The Seven Base Units

Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric Current	ampere	A
Temperature	kelvin	K
Amount of Substance	mole	mol
Luminous Intensity	candela	cd

Definitions of Base Units

second	The second, symbol s, is the SI unit of time. It is defined by taking the fixed numerical value of the caesium frequency ΔvCs, the unperturbed ground-state hyperfine transition frequency of the caesium-133 atom, to be 9,192,631,770 when expressed in the unit Hz, which is equal to s^{-1}.
metre	The metre, symbol m, is the SI unit of length. It is defined by taking the fixed numerical value of the speed of light in vacuum c to be 299,792,458 when expressed in the unit $m{\cdot}s^{-1}$, where the second is defined in terms of the caesium frequency ΔvCs.

Definitions of Base Units (cont)

kilogram	The kilogram, symbol kg, is the SI unit of mass. It is defined by taking the fixed numerical value of the Planck constant h to be $6.62607015 \times 10^{-34}$ when expressed in the unit J·s, which is equal to $kg \cdot m^2 \cdot s^{-1}$, where the metre and the second are defined in terms of c and ΔvCs.
ampere	The ampere, symbol A, is the SI unit of electric current. It is defined by taking the fixed numerical value of the elementary charge e to be $1.602176634 \times 10^{-19}$ when expressed in the unit C, which is equal to A·s, where the second is defined in terms of ΔvCs.
kelvin	The kelvin, symbol K, is the SI unit of thermodynamic temperature. It is defined by taking the fixed numerical value of the Boltzmann constant k to be 1.380649×10^{-23} when expressed in the unit $J \cdot K^{-1}$, which is equal to $kg \cdot m^2 \cdot s^{-2} \cdot K^{-1}$, where the kilogram, metre and second are defined in terms of h, c and ΔvCs.

Definitions of Base Units (cont)

mole	The mole, symbol mol, is the SI unit of amount of substance. One mole contains exactly $6.02214076 \times 10^{23}$ elementary entities. This number is the fixed numerical value of the Avogadro constant, N_A, when expressed in the unit mol^{-1} and is called the Avogadro number. The amount of substance, symbol n, of a system is a measure of the number of specified elementary entities. An elementary entity may be an atom, a molecule, an ion, an electron, any other particle or specified group of particles.
candela	The candela, symbol cd, is the SI unit of luminous intensity in a given direction. It is defined by taking the fixed numerical value of the luminous efficacy of monochromatic radiation of frequency 540×10^{12} Hz, Kcd, to be 683 when expressed in the unit $lm \cdot W^{-1}$, which is equal to $cd \cdot sr \cdot W^{-1}$, or $cd \cdot sr \cdot kg^{-1} \cdot m^{-2} \cdot s^3$, where the kilogram, metre and second are defined in terms of h, c and ΔvCs.

Not necessary information

Prefixes and Orders of Magnitude

The SI system also establishes a set of twenty prefixes to unit names and unit symbols
that may be used when specifying multiples and fractions of the units. This is useful for expressing physical quantities that are either very big or very small.

Table of Prefixes

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

In O-Levels, the only prefixes that you need to know are nano, micro, milli, centi, deci, kilo, mega and giga.

Examples of Orders of Magnitudes

3,900 YHz	Highest energy gamma wave ray detected
30.86 Zm	One gigaparsec
30 Eg	Mass of the rings of Saturn
30 PHz	Frequency of an X-Ray
9.461 Tm	The distance light travels in a year
0.3 Gm/s	Speed of light in a vacuum
12.742 Mm	Diameter of the earth
16.5 kN	Bite force of a 5.2m Saltwater Crocodile
2.4 hg	Average mass of a grand piano
7 dag	Average mass of an adult human
1.1 dJ	Energy of an American half-dollar falling 1 metre
1.6667 cHz	1 rpm
2.75 mm/s	Fastest recorded speed of a snail
0.3 μm/s	Calculated speed of an amoeba (lower bound)
1.6 nN	Force required to break a typical covalent bond
50 pK	Lowest temperature produced
1 fg	Mass of a HIV-1 virus
1.65 ag	Mass of double-stranded DNA molecule consisting of 1,578 base pairs

Examples of Orders of Magnitudes (cont)

3 zJ	Energy of a van der Waals interaction between atoms
0.0000-00000016 ym	One Planck length