STAMP 3.0 (For internal use only)
Year 3

Physics: Units and Measurement; Electromagnetic Waves

Units and Measurement

Summary

SI units:

Length	Metre (m)
Mass	Kilogram (kg)
Time	Second (s)
Electric current	Ampere (A)
Temperature	Kelvin (K)
Amount of Substance	Mole (mol)
Luminosity	Candela (cd)

Note: gram (g), degrees Celsius (°C), coulomb (C) are NOT SI units.

Some names are reserved for special quantities that are *derived units*, in the sense that they can be derived from a combination of SI units.

Example: Force is mass times acceleration, which in SI units is kg m s^{-2}, and has a special name assigned to this unit called Newton (N).

Prefixes:

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

Uncertainty: Measurements have uncertainties, as there is limited precision in the instrument, or there is an inherent randomness of quantity measured.

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Systematic error: an error that results in the measured values being always higher or always lower than the true value. Example: Mistimed action; Zero error

Error is reduced by subtracting off the constant deviation.

Random error: an error that results in the measured values being scattered about the true value. Example: Count-rate of a radioactive source.

Error is reduced by taking average of multiple measurements.

For calculations with multiplication/division, the answer should be in the **lowest significant figure (S.F.)**

For calculations with addition/subtraction, the answer should be in the **lowest decimal place (D.P.)**

Zero error guide: Always take the zero error as the measured value when the instrument measuring a value of a true value of zero. This means that it could be negative.

To get the true value, take the measured value of a certain measurement – (zero error). This means that if the zero error is negative (e.g. -2), you add it to the measured value instead. (x + 2)

Exercise

Convert the following:

a) 30km/h _____ m/s

b) 63nm _____ km

c) 477kN _____ g m s^{-2}

d) 100mA _____ A

e) 1000kg m^{-1} s^{-2} _____ g m^{-1} h

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Electromagnetic Waves

A wave is a disturbance that travels through a medium from one location to another, transporting energy but not mass. Mechanical waves require a medium, but *electromagnetic waves* do not.

Displacement is the distance of the oscillating particle in a wave from its equilibrium position at any instant.

Amplitude is the maximum displacement of the oscillating particle in a wave from the equilibrium position.

Period is the time taken to complete one oscillation of the wave.

Frequency is the number of oscillations per unit time. Unit is hertz (Hz), which is s^{-1}.

Wavelength λ is the distance between corresponding points in successive waveforms.

Phase difference is the difference in stages of oscillation between two waves at two points on the wave.

Longitudinal waves such as sound waves vibrate particles in a direction parallel to the direction of propagation of wave.

Transverse waves such as EM waves vibrate particles in a direction perpendicular to the direction of propagation of wave.

Crest/peak: high point of a wave

Trough: low point of a wave

Speed distance travelled by wave in a second.

Equations: $f = \frac{1}{t}$, $v = \frac{\lambda}{t} = f\lambda$

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Electromagnetic spectrum

Type	Wavelength	Frequency	Application
Radio waves	> 1m	<300 MHz	Radio and TV Wireless Mobile phones
Microwaves	1mm – 1m	300MHz – 300GHz	Microwave Oven Satellite TV Telephone
Infra-red waves	760nm – 1mm	300GHz – 400THz	Household electrical appliances Night vision
Visible light	380nm – 760nm	400THz – 800THz	Optical Fibres Telecommunications
Ultra-violet	10nm – 380nm	800THz – 30PHz	Sun beds Fluorescent tubes
X-rays	0.01nm – 10nm	30PHz – 30EHz	Hospital use Airport security
Gamma rays	< 0.01nm	> 30EHz	Sterilising medical equipment Cancer treatment

Note: If a body absorbs high-energy electromagnetic waves (KE = ½ mv^2, thus higher speed is higher energy, thus higher frequency is higher energy) such as X-rays or gamma rays, the electrons may damage living cells and tissues.

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