**Waves & Radiation**

**The Electromagnetic Spectrum**

**Summary**

Electromagnetic radiation is an oscillation of electrical and magnetic fields that travels through space as a wave and carries energy

The **electromagnetic spectrum** is the range of all possible frequencies of electromagnetic radiation.

The electromagnetic spectrum is split into several regions, according to its wavelength (or frequency). Different regions of the spectrum require different detectors and have different applications.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| decreasing wavelength | Region | Detector(s) | Applications | increasing frequency |
| Radio | aerial | communication (e.g. broadcast radio)MRI scanners |
| Microwave | aerial | satellite communication (e.g. satellite TV)mobile phone communicationWifiradarGPS |
| Infrared | photodiode | night visionthermogramsremote controls |
| Visible light | the eyephotodiodephotographic film | eyesightphotographylasers (e.g. surgery,  |
| Ultraviolet | photodiodephotographic film | fluorescence (e.g. security markings)treatment of skin conditionssterilisation of medical instrumentsexcessive exposure causes skin cancer |
| X-rays | photographic film | radiographs (internal images of objects/people)radiotherapy (treatment of cancer) |
| Gamma | Geiger-Muller tubephotographic film | treatment of cancerradioactive tracers |

All waves in the electromagnetic spectrum travel at the same speed (300000000 meters per second in a vacuum), but have different wavelengths and frequencies.

**Distance, Speed and Time**

$$speed=\frac{distance}{time}$$

$$v=\frac{d}{t}$$

$$d=vt$$

$$t=\frac{d}{v}$$

m

m/s

s

*v*

*d*

*t*

**Speed, Frequency and Wavelength**

$$speed=frequency × wavelength$$

$$v=fλ$$

$$f=\frac{v}{λ}$$

$$λ=\frac{v}{f}$$

*f*

*v*

*λ*

m/s

Hz

m

Since the frequencies of electromagnetic waves are often very large, and their wavelengths can be very small, it is common to use prefixes for their units.

|  |  |  |
| --- | --- | --- |
| *Prefix* | *Symbol* | *Factor* |
| giga | G | 1000000000 = 109 |
| mega | M | 1000000 = 106 |
| kilo | k | 1000 = 103 |
| milli | m | 0·001 = 10-3 |
| micro | μ | 0·000001 = 10-6 |
| nano | n | 0·000000001 = 10-9 |