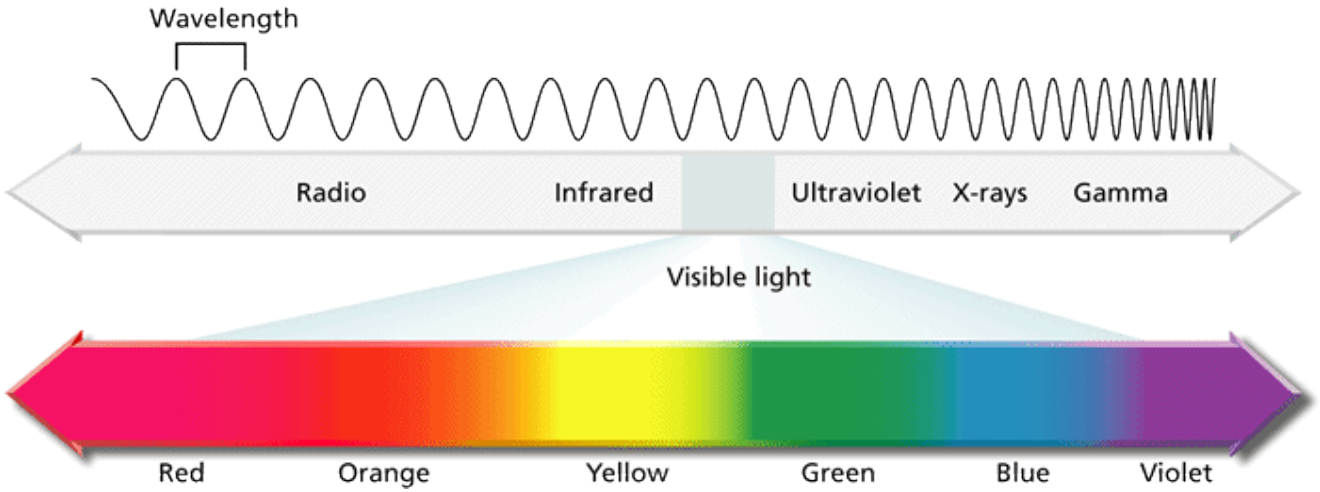
Electromagnetic Spectrum

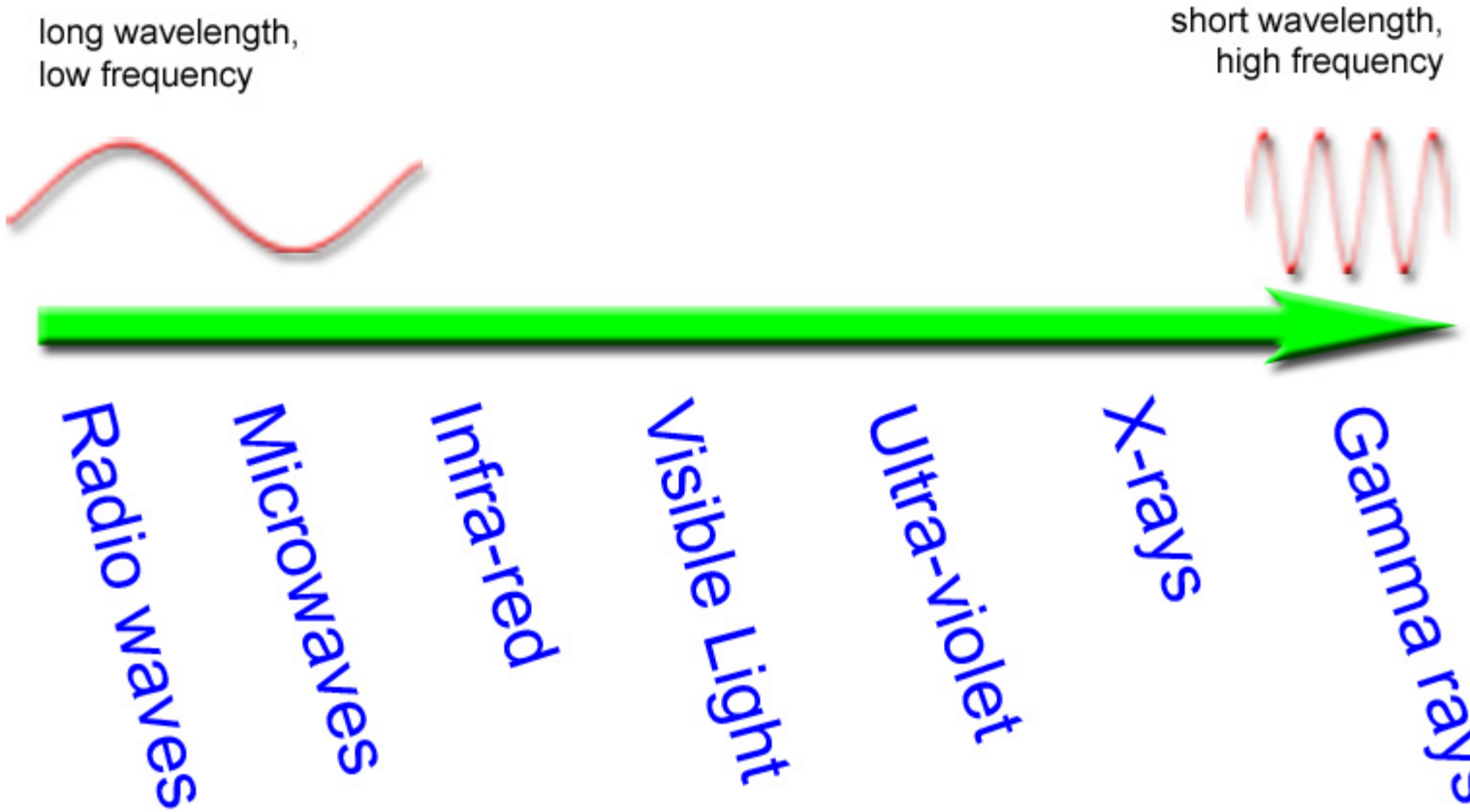


- Scientists have found that many types of wave can be arranged together like the notes on a piano keyboard, to form a scale.
- The 'low notes' have a low frequency and a long wavelength.
- The 'high notes' have a high frequency and a short wavelength.
- When we say "wave", you might think of a wave on the sea. There, it's nice and obvious what's going on - the surface of the sea is vibrating up and down.
- With a sound wave, it's the air particles that are vibrating.
- So what's vibrating when an electromagnetic wave passes by?
  That's not so easy.
  Electromagnetic waves are vibrations of magnetic and electric fields.
- So they don't need air in order to travel. They don't need anything to be there at all.



Caution: don't get too hung up on this keyboard idea - sound waves are NOT part of the electromagnetic spectrum

How do the waves fit into the electromagnetic spectrum?



All of these are "electromagnetic waves".
This means that although they appear to be very different, in fact they're all made of the same kind of vibrations - but at **different frequencies**.

What do "wavelength" and "frequency" mean?

Wavelength means pretty much what it says - the length of one wave.

More precisely, it means the **distance from the peak of one wave to the peak on the next wave**.
Strictly speaking, "the distance from any point on a wave to the same point on the next cycle of the wave". The peaks are just handy places to measure from.

It may be measured in:

kilometres	km	1,000 metres
metres	m	*Awww, come on, you know how big a metre is!*
centimetres	cm	A hundredth of a metre. But you know this already.
millimetres	mm	1/1000th of a metre. Those tiny lines on your ruler!
nanometres	nm	1/1000,000,000th of a metre. Or, if you prefer, a millionth of a millimetre. Small!

Frequency is a word used in Maths to mean "how often something happens".

With waves, it's "**how many waves per second**"

It may be measured in:

Hertz	Hz	1 Hz means 1 wave per second
kilohertz	kHz	1 kHz is 1,000 waves per second
megahertz	MHz	1 MHz is 1 million waves per second. Your favourite FM radio station probably broadcasts around 100 MHz
gigahertz	GHz	1 GHz is 1,000 million waves per second. Microwaves are around a few GHz.

Radio Waves: How they're made

- Radio waves are made by various types of **transmitter**, depending on the wavelength. They are also given off by stars, sparks and lightning, which is why you hear interference on your radio in a thunderstorm.

Uses of Radio Waves

Radio waves are the lowest frequencies in the electromagnetic spectrum, and are used mainly for **communications**.



Radio waves are divided into:-

- **Long Wave**, around 1~2 km in wavelength. The radio station "Atlantic 252" broadcasts here.
- **Medium Wave**, around 100m in wavelength, used by BBC Radio 5 and other "AM" stations.
- **VHF**, which stands for "Very High Frequency" and has wavelengths of around 2m. This is where you find stereo "FM" radio stations, such as BBC Radio 1and Further up the VHF band are civilian aircraft and taxis.
- **UHF** stands for "Ultra High Frequency", and has wavelengths of less than a metre. It's used for Police radio communications, television transmissions and military aircraft radios - although military communications are now mostly digital and encrypted.

Microwaves – How They are Made

- Microwaves are basically extremely high frequency radio waves, and are made by various types of **transmitter**.
- In a mobile phone, they're made by a transmitter chip and an antenna, in a microwave oven they're made by a "magnetron".
- Their wavelength is usually a couple of centimeters. Stars also give off microwaves.





Infrared – How it’s made



Infra red waves are just below visible red light in the electromagnetic spectrum ("Infra" means "below").

You probably think of Infra-red waves as heat, because they're given off by **hot objects**, and you can feel them as warmth on your skin.

Infra Red waves are also given off by **stars**, **lamps**, **flames** and anything else that's warm - including you.



The detector on this security light picks up the Infra red radiation from your body.

Visible Light



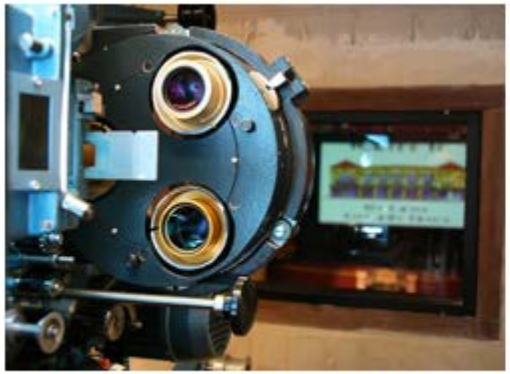
Our eyes can detect only a **tiny** part of the electromagnetic spectrum, called **visible light**.

This means that there's a great deal happening around us that we're simply not aware of, unless we have instruments to detect it.

Light waves are given off by **anything that's hot enough to glow**.

This is how light bulbs work - an electric current heats the lamp filament to around 3,000 degrees, and it glows white-hot.

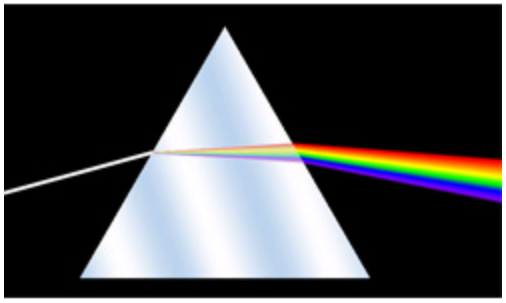
The surface of the Sun is around 5,600 degrees, and it gives off a great deal of light.



Cinema projectors use a powerful lamp



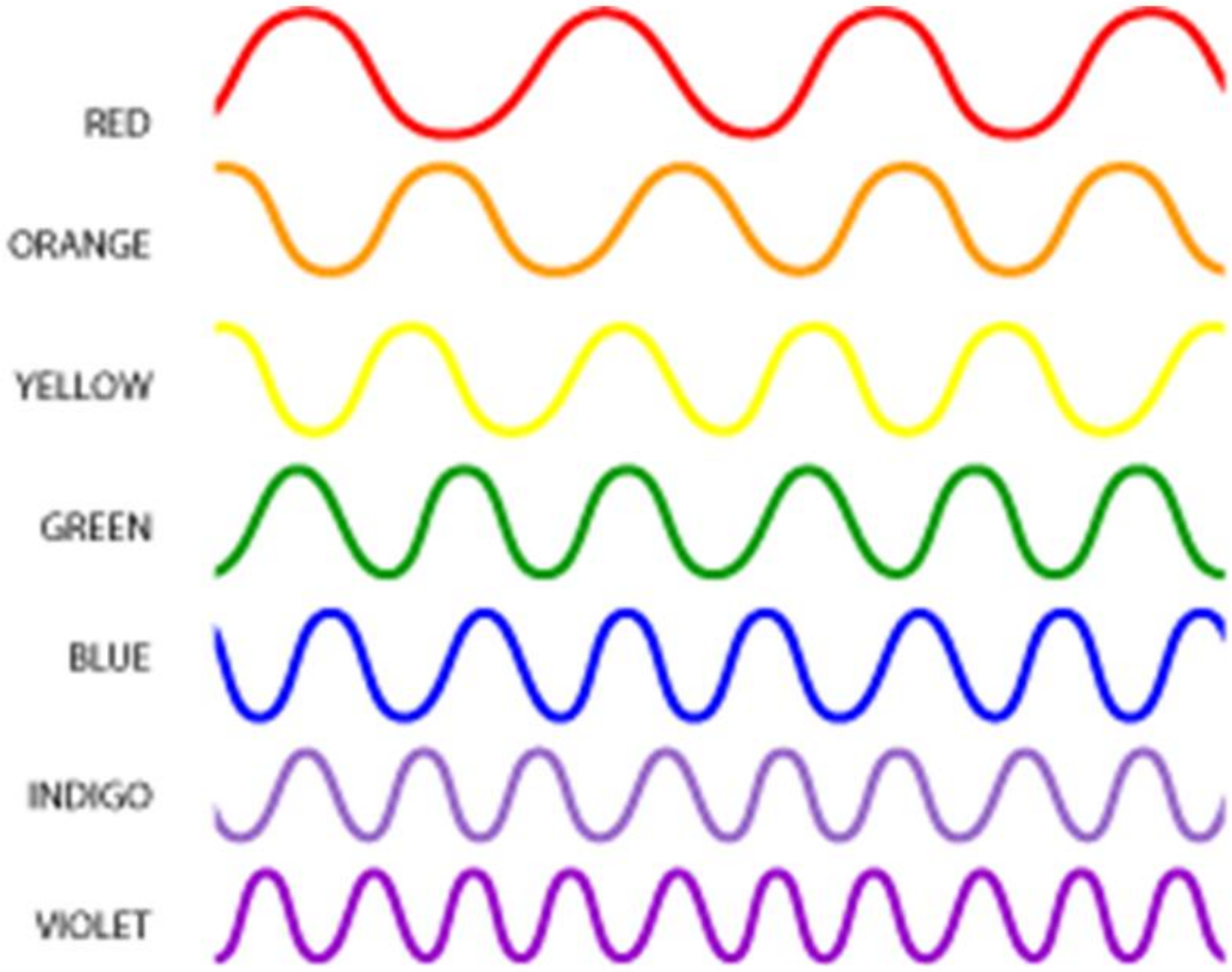
This filming lamp has a 'colour temperature' of 3000K



White Light

- White light is actually made up of a whole range of colors, mixed together.
- We can see this if we pass white light through a glass prism - the violet light is bent ("refracted") more than the red, because it has a shorter wavelength - and we see a rainbow of colors.
- This is called 'dispersion', and allows us to work out what stars are made of by looking at the mixture of wavelengths in the light.

Wavelengths



Uses of Visible Light

We use light to **see things**! As the Sun sends so much light towards our planet, we've evolved to make use of those particular wavelengths in order to sense our environment.



Light waves can also be made using a laser. This works differently to a light bulb, and produces "coherent" light.

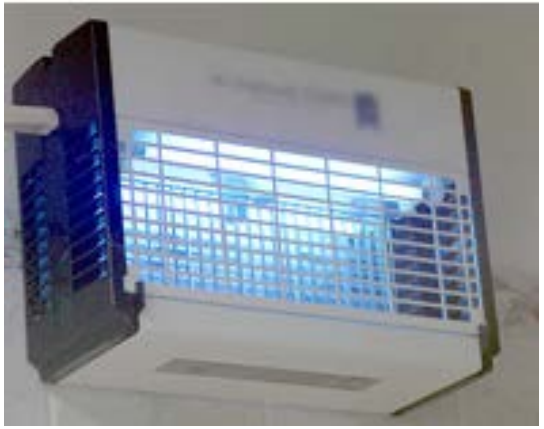
Lasers are used in **Compact Disc & DVD players**, where the light is reflected from the tiny pits in the disc, and the pattern is detected and translated into sound or data.

Lasers are also used in **laser printers**, and in aircraft **weapon aiming systems**.



UV – How it’s made

- Ultra-Violet light is made by **special lamps**, for example, on sun beds. It is given off by the **Sun** in large quantities. **We call it "UV" for short**.
- The photo shows a UV lamp. The lamp gives off UV (which you can't see) as well as violet light (which you can see).
- The UV attracts insects, which are electrocuted by high-voltage wires near the lamp - so they won't land on the food and contaminate it.

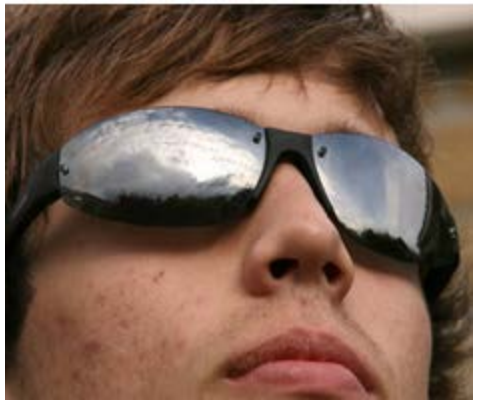


Uses of UV Radiation



- Uses for UV light include getting a **sun tan**, **detecting forged bank notes** in shops, and hardening some types of dental filling.
- You also see UV lamps when they make your clothes glow. This happens because substances in washing powder "fluoresence" when UV light strikes them - they absorb the UV and then re-radiate the energy at a longer wavelength. The lamps are sometimes called "black lights" because we can't see the UV coming from them.
- When you mark your possessions with a security marker pen, the ink is invisible unless you shine a UV lamp at it.
- Ultraviolet rays can be used to **kill microbes**. Hospitals use UV lamps to sterilize surgical equipment and the air in operating theatres. Food and drug companies also use UV lamps to **sterilize** their products.
- Suitable doses of Ultraviolet rays **cause the body to produce vitamin D**, and this is used by doctors to treat vitamin D deficiency and some skin disorders.

Dangers of UV



Large doses of UV can **damage the retina** in your eyes, so it's important to check that your sunglasses will block UV light.

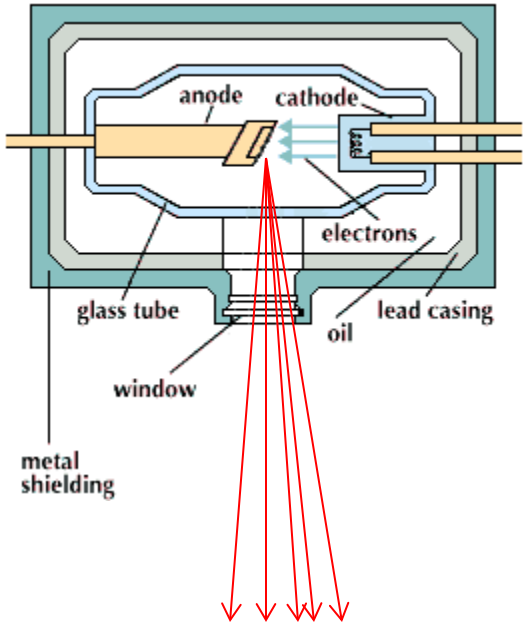
The cheaper sunglasses tend not to protect you against UV, and this can be really dangerous. When you wear sunglasses the pupils of your eye get bigger, because less light reaches them.

This means that if your sunglasses don't block UV, you'll actually get **more** ultra-violet light in your eyes than if you didn't wear them, although you won't notice at the time. So before you buy sunglasses, check that they offer UV protection!

Large doses of UV cause **sunburn** and even **skin cancer**. Fortunately, the ozone layer in the Earth's atmosphere screens us from most of the UV given off by the Sun. Think of a sun tan as a radiation burn!

X-Rays

- X-rays are very high frequency waves, and carry a lot of energy. They will pass through most substances, and this makes them useful in medicine and industry to see inside things.
- X-rays are given off by **stars**, and strongly by some types of nebula.
- An **X-ray machine** works by firing a beam of electrons at a "target". If we fire the electrons with enough energy, X-rays will be produced.



X-Ray