

Electromagnetic Waves Notes

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Electromagnetic waves: are transverse waves that are made of oscillating (vibrating) electric **and** magnetic fields. The fields are perpendicular to each other and to the direction of the wave's propagation.

A medium: the matter that waves are traveling through.

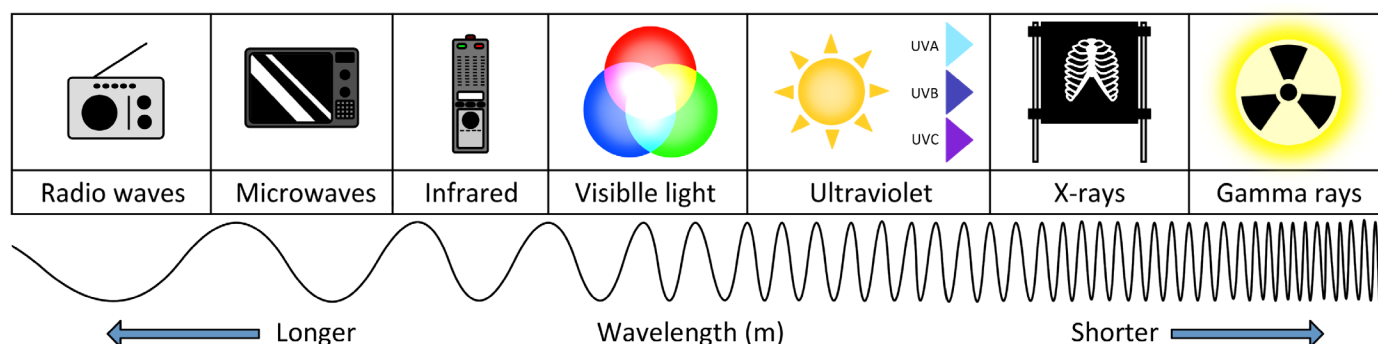
Mechanical waves versus electromagnetic waves

Electromagnetic waves are **not** mechanical waves like water waves or sound waves.

Mechanical waves, like water or sound waves, are caused by a vibration in matter, whether it's solid, liquid or gas. Mechanical waves need a medium to propagate through. Mechanical waves travel through a medium by causing the particles of the medium to collide into each other. As they collide into each other, they transfer energy from particle to particle. Sound waves cannot travel through the vacuum of space because there is no medium for these mechanical waves to propagate.

Electromagnetic waves are different, they do not require a medium to propagate. This means that electromagnetic waves can travel through solids, liquids and gases as well as the vacuum of space.

The Electromagnetic Spectrum



Uses of Each Electromagnetic wave

Radio waves (wavelength: $> 1 \text{ mm}$) – are used in communication. For example, walkie talkies and radios.

Microwaves (wavelength: 1 mm to 1 m) – are used in cooking and communication.

Microwaves are used for satellite communication because they can pass through the Earth's atmosphere and ionosphere without being significantly reflected or distorted.

Infrared waves (wavelength: 700 nm to 1 mm) – are used in remote controls, thermal imaging systems and heaters. It is also used in cooking.

Visible light (wavelength: 400 nm to 700 nm) – is used for anything that involves sight. So traffic lights and fibre optical cables are really good examples but literally anything that involves sight for this one 😊

Ultraviolet light (wavelength: 10 nm to 400 nm) – is used for tanning beds, sterilising some objects and as a security feature on money. Certain parts of money will glow when UV light is shined on to them, showing it is real.

X-rays (wavelength: 0.01 nm to 10 nm) – are used for medical scans and security systems at airports. Please don't say x-rays are used for x-rays. You won't get a mark for this in the exam, say they are used for medical scans 😊

Gamma rays (wavelength: $< 0.01 \text{ nm}$) – have a large number of uses. They are used in medical scans (PET scans), cancer treatment (radiotherapy) and sterilising medical equipment that can't be heat treated. They can also be used to sterilise food before transporting it so that the food doesn't go off at its being transported.

Risks of Electromagnetic waves

As EM waves transfer energy they can potentially be dangerous. But, before we look at the risks and the ways we can reduce them. We should know these two definitions.

Ionising radiation: radiation that is able to cause a charge (positive or negative) on another object. It does this by knocking electrons off of the atoms that it collides with.

This is the radiation that is the bad radiation. Our cells and our DNA don't like to be charged so this can cause damage to our cells, this can also cause our cells to keep making more of themselves, this is a cancer.

Penetration power: the ability of radiation to pass through or penetrate a material.

Microwaves: can cause burns. There can be issues with long term exposure.

Infrared waves: can cause burns.

Visible light: no significant dangers here. Except lasers, they can damage the eye.

Ultraviolet light: overexposure to UV can cause skin damage such as sunburn and premature ageing of the skin. There is also an increased risk of skin cancer. UV radiation can also cause damage to the eyes with long term exposure.

How can we reduce the risk: use suncreams and try to avoid being out when the sun is most intense.

X-rays: are ionising and have a high penetration power. As x-rays are ionising, they can damage the DNA, causing it to mutate. This could lead to a cancer developing.

How can we reduce the risk: use a lead shield or lead apron. If you ever need to have an x-ray you might notice the person doing it often stands behind a big screen, might leave the room altogether. Or they can wear a lead apron or vest. All of these methods are meant to absorb the radiation. This reduces the persons exposure to x-rays.

Gamma rays: are ionising and have a very high penetration power. As they can pass through materials easily they can be dangerous if there is a lot of exposure. Gamma rays are not very ionising at all but lots of exposure can increase the chances of a cancer developing.

How can we reduce the risk: again using a lead shield or lead apron, or some type of radiation absorbing material.

Radiation Exposure

Being exposed to ionising forms of radiation can be quite dangerous. Especially if there is a lot of exposure over a long period of time. In general, the more exposure a person has the more likely they are to develop health issues related to ionising radiation. Does this exposure have a measurement? Yes, it's called a sievert.

A sievert: a measure of the amount of radiation a person is exposed to.

One sievert is actually quite a significant amount of radiation exposure, this can cause health problems such as an increased risk of cancer developing. As one sievert is a lot we tend to measure radiation exposure in millisieverts.

$$1000 \text{ millisieverts (mSv)} = 1 \text{ sievert (Sv)}$$

Who is at risk of being exposed to large amounts of radiation? People who are having radiotherapy for cancer treatment and people who work in nuclear power stations. Also people who lived near the site of a nuclear accident such Chernobyl or Fukushima.