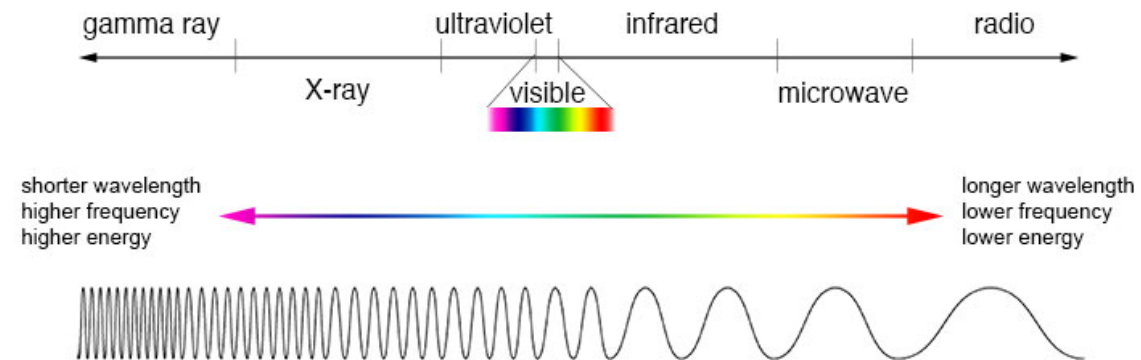


6.2.2 Uses of electromagnetic waves

There is a range of different electromagnetic (EM) waves. This is called the EM spectrum. The only difference in these waves is their wavelength.



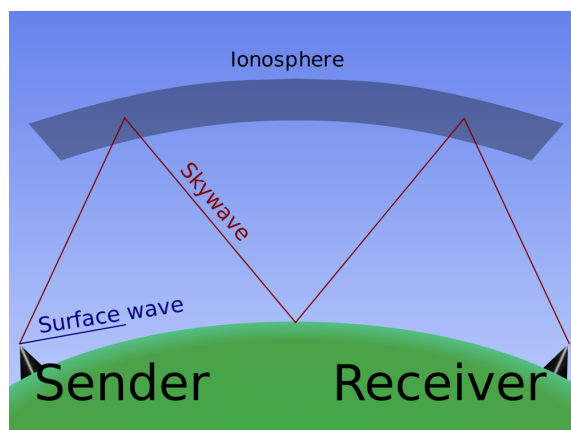
videos



Electromagnetic (EM) waves have various different uses.

Radio

Radio waves are used to transmit radio and television signals.



Long wave radio signals can reflect off a layer in the atmosphere called the “ionosphere”. This allows radio signals to pass around the curvature of the Earth.

(1) ✍ Why are long wave radio signals not used to communicate with artificial satellites in orbit around the Earth?

(2) ✍ BBC Radio One broadcasts on the FM frequency of 94.9MHz (megahertz = 10^6 Hz). What is the wavelength of the radio waves at this frequency? (Hint: Use the wave equation, and the speed of light ($=3.0 \times 10^8$ m/s)).

Microwave

Microwaves are used to communicate with satellites because they can pass relatively easily through the ionosphere and the rest of the atmosphere. Because they have shorter wavelength than radio, they also have a greater capacity for carrying information.

Microwaves also cause charges to oscillate. In a microwave oven, water molecules (being dipolar) are forced to oscillate. This heats up the food.

(3) *Why can't metallic objects be placed in a microwave oven? (Hint: Think about what microwaves do to charges.)*

Infrared

Hot objects emit infrared radiation. Electric heaters, toasters and filament lightbulbs all emit infrared radiation. We can't detect infrared with our eyes, but we can often feel it with our skin. Some cameras are sensitive to infrared. This can be useful, as they can be used as 'night vision' cameras. For example, police can use a night vision camera to locate a person in the dark by the heat emitted from their body.

(4) *In what other situation could an infrared camera be useful?*

Infrared can also be used to send signals. For example, remote controls for televisions use infrared signals. They can also be used to carry digital information along optical fibres.

(5) *What would you expect to see if you observed the front of a working remote control with an infrared camera?*

Visible

Apart from seeing, and devices that use light (e.g. telescope, microscope), visible light is often used to send digital signals along optical fibres. The signal consists of a series of flashes (a bit like Morse Code). The advantage of this over electrical signals is that far more information can be sent in a given time.

(6) *Why are much greater Broadband speeds achievable with optical fibre?*

Ultraviolet

Ultraviolet is used in sun beds. The UV radiation causes the skin to tan. However, some of the UV radiation carries enough energy to damage skin cells and can increase the risk of developing skin cancer.

(7) *Why is it important to use sun cream on a sunny day? What does it protect you from?*

UV radiation can cause some materials to fluoresce (give out visible light). This effect is used in fluorescent lighting. They work by passing a current through a gas (in the tube) which produces UV radiation. The UV hits a fluorescent coating on the inside of the tube causing it to emit visible light.

(8) ✍ *Why are fluorescent lamps preferable to filament lamps?*

X-ray

X-rays are used in medical imaging to produce shadow pictures of dense objects (such as bones and teeth). A sheet of film is placed on one side of a patient and the X-rays shone through the patient from the other side. X-rays pass through the soft tissue of the patient but are blocked (absorbed) by dense materials.



This leaves a shadow on the photographic film.

(9) ✍ *What colour does the X-ray film go when it is struck by X-rays?*

X-rays are ionising radiation.

(10) ✍ *What does 'ionising' mean?*

Ionising radiation can damage the DNA in cells, leading to cell mutation and cancer.

Computerised Tomography (CT) scans use multiple X-ray pictures, taken from different angles, to build up a 3D image of the subject.

(11) ✍ *Why do you think that CT scans are used very sparingly?*

Gamma

Gamma radiation is the most energetic, and most ionising EM wave. It can be used to kill cancer cells, in 'radiotherapy'. It can also be used to sterilise surgical equipment. In this case the surgical equipment (in sealed bags) is passed through a strong beam of gamma radiation. Any bacteria are killed, leaving the contents of the bag sterile.

(12) ✍ *Why do you think the equipment needs to be in a sealed bag?*

Gamma radiation can also be used as a tracer. A weak radioactive source (of gamma radiation) is injected into the patient. As the source is emitting gamma radiation, this can pass out through the body and be detected using a gamma camera. This means that the source can be tracked (traced) as it moves through the body. The chemistry of a tracer affects where it ends up in the body. For example, iodine is removed from the blood by the kidneys. A radioactive iodine tracer can therefore be used to monitor how well the kidneys are functioning.

(13) ✎ *Why do you think medical staff need to leave the room once the tracer has been injected and the camera is operating?*