Uses and applications of electromagnetic waves

6.6.2.4 · Physics · revision notes

The practical uses of each part of the electromagnetic spectrum and, at Higher tier, why each type of wave is suitable for its use. Expect 'give a use' recall questions, and 2 to 3 mark 'explain why' questions at Higher tier.

Key facts

- Radio waves: television and radio
- Microwaves: satellite communications, cooking food
- Infrared: electrical heaters, cooking food, infrared cameras
- Visible light: fibre optic communications
- Ultraviolet: energy-efficient lamps, sun tanning
- X-rays and gamma rays: medical imaging and treatments
- Grade 7+ only X-rays: transmitted by soft tissue, absorbed by bone
- Grade 7+ only Microwaves: pass through the atmosphere to satellites; absorbed by water in food

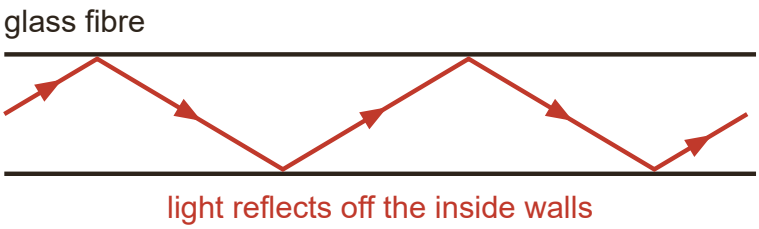
Notes

Uses of each type of EM wave

- **Radio waves**: television and radio.
- **Microwaves**: satellite communications; cooking food.
- **Infrared**: electrical heaters; cooking food; infrared cameras.
- **Visible light**: fibre optic communications.
- **Ultraviolet**: energy-efficient lamps; sun tanning.
- **X-rays and gamma rays**: medical imaging and medical treatments, such as killing cancer cells.

Why each type is suitable Grade 7+ only

- **Radio waves** travel long distances through the air and pass through walls, and they are easy to produce and detect with aerials in electrical circuits.
- **Microwaves** pass through the Earth's atmosphere, so signals can travel between the ground and satellites in space. In an oven, microwaves pass a few centimetres into food and are absorbed by the water molecules in it, which heats the food.
- **Infrared** is absorbed by the surfaces of objects and food, transferring energy to their thermal energy stores. All objects emit infrared and hotter objects emit more, so an infrared camera shows different temperatures as different colours, even in the dark.
- **Visible light** travels along thin glass fibres by reflecting off the inside walls, and little of it is absorbed by the glass, so signals can be sent a long way.



Visible light in an optical fibre: little is absorbed, so signals travel far.

- **Ultraviolet**: in an energy-efficient lamp, ultraviolet produced inside the tube is absorbed by a coating on the glass, which then gives out visible light. Much less energy is wasted than in a filament lamp. Ultraviolet absorbed by skin makes it tan.
- **X-rays** pass easily through soft tissue but are absorbed by bone, so bones show up clearly on the detector.
- **X-rays and gamma rays** are ionising and carry a lot of energy, so a carefully aimed beam can kill cancer cells.

How to answer each type of question

Give a use of a type of EM wave 1 mark each **Grade 3**

1. Give one specific use, as listed in the specification.
2. Make sure it matches the wave named in the question.

Example. Give **one** use of each type of electromagnetic wave.
(a) infrared
(b) ultraviolet
(c) microwaves

Model answer.

(a) Electrical heaters / cooking food / infrared cameras (1)
(b) Energy-efficient lamps / sun tanning (1)
(c) Satellite communications / cooking food (1)

Explain why a type of EM wave suits a use

2 marks | Grade 7

1. State the property of the wave: what it passes through and what absorbs it.
2. Link the property to the use with 'so'.

Example. Explain why X-rays are used to produce images of broken bones.

Model answer. X-rays pass through soft tissue such as skin and muscle but are absorbed by bone (1). So the bones show up clearly on the detector, and the break can be seen (1).

Explain how an application works

3 marks | Grade 7

1. Say where the waves go (e.g. into the food).
2. Say what absorbs them.
3. Say what the absorbed energy does.

Example. Explain how a microwave oven heats food.

Model answer. The microwaves pass a few centimetres into the food (1). They are absorbed by water molecules in the food (1). This transfers energy to the food, increasing its temperature (1).

Explain a use and its risk

3 marks | Grade 8

1. Give the property that makes the wave useful.
2. Give the effect on the target (e.g. cancer cells).
3. Give the risk to healthy tissue and how it is reduced.

Example. Gamma rays can be used to treat cancer, but they are also a hazard to healthy tissue. Explain why gamma rays can treat cancer and why the beam is carefully aimed at the tumour.

Model answer. Gamma rays are ionising and carry a lot of energy (1), so they can damage and kill cancer cells (1). They can also damage healthy cells and cause mutations, so the beam is aimed to keep the dose to healthy tissue as small as possible (1).

Don’t lose marks

- Mixing up infrared and ultraviolet uses, e.g. saying 'ultraviolet cameras' for seeing warm objects in the dark.
- Saying microwaves heat food only at the surface. They pass a few centimetres in and are absorbed by the water there.
- Giving a use without any explanation when the question says 'explain why'.
- Saying X-rays are reflected by bones. They are absorbed.

More tips

Memory tricks

- Walk along the spectrum saying one use for each: radio for radio and TV, micro for satellites and cooking, infrared for heaters and cameras, visible for fibre optics, ultraviolet for lamps and tanning, X-rays and gamma for hospitals.
- For 'why is it suitable', ask two questions: what does it pass through, and what absorbs it?
- Both microwaves and infrared cook food: microwaves are absorbed by water a few centimetres into the food; infrared is absorbed at the surface.

Exam technique

- For 'give a use', one specific use is enough, e.g. 'satellite communications' for microwaves.
- In Higher tier 'explain' questions, give the property and then its consequence, joined with 'so' or 'because'.
- Learn the uses exactly as the specification lists them: they are the answers examiners expect.

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 3 — **Match each EM wave to a use**
E.g. radio waves: television and radio; X-rays: medical imaging.

Grade 4 — **Give two uses of microwaves**
Satellite communications and cooking food.

Grade 4 — **Give three uses of infrared**
Electrical heaters, cooking food and infrared cameras.

Grade 5 — **Give uses of visible light and ultraviolet**
Visible light: fibre optic communications. Ultraviolet: energy-efficient lamps and sun tanning.

Grade 7 — **Explain why microwaves suit satellite communications**
Microwaves pass through the Earth's atmosphere, so they can reach satellites in space.

Grade 7 — **Explain why X-rays suit imaging bones**
X-rays pass through soft tissue but are absorbed by bone, so bones show up on the image.

Grade 8 — **Explain why gamma rays treat cancer**
Gamma rays are ionising and carry a lot of energy, so a carefully aimed beam can kill cancer cells.

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