Exercise walk-through

Electromagnetic spectrum ▪ 7.4

eXercise

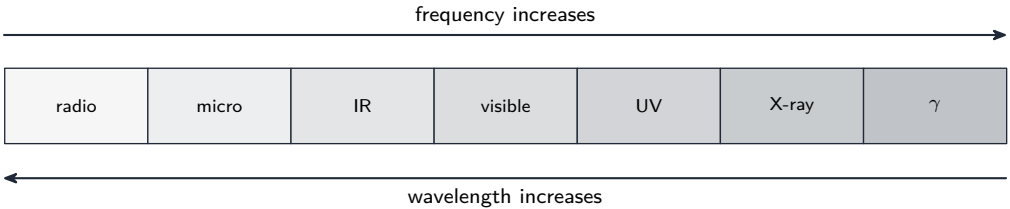
You must be able to

- state that all EM waves are **transverse** and travel at c in a vacuum
- order the regions from **radio** to γ-**rays** by wavelength/frequency
- use $c = f\lambda$ and recall visible light is 400–700 nm

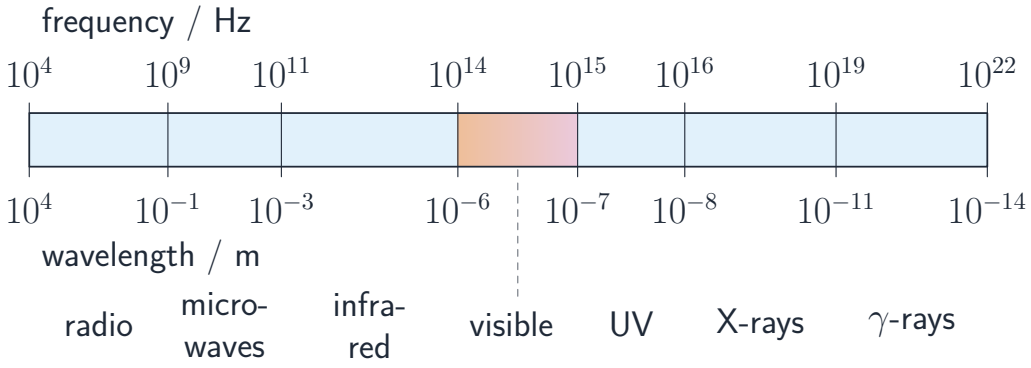
Method — EM waves and the spectrum

All EM waves are **transverse** and travel in a vacuum at $c = 3.00 \times 10^8$ m s^{-1}. In order: Approximate wavelengths (learn the orders of magnitude): radio $> 10^{-1}$ m; microwaves 10^{-3}–10^{-1} m; IR up to $\sim 7 \times 10^{-7}$ m; **visible** 400–700 **nm**; UV $\sim 10^{-8}$–4×10^{-7} m; X-rays $\sim 10^{-11}$–10^{-8} m; γ-rays $< 10^{-11}$ m.
Use $c = f\lambda$ to convert between wavelength and frequency.

Method — EM waves and the spectrum



Method — EM waves and the spectrum



The electromagnetic spectrum

Practice 2.1 ▪ 2 marks

State **two** properties common to **all** electromagnetic waves.

Solution 2.1

Method: EM waves and the spectrum

Worked steps

Any two: they are **transverse**; they travel at the **same speed** c in a vacuum; they can travel through a vacuum B1 B1.

Practice 2.2 ▪ 1 mark

State the speed of EM waves in a **vacuum**.

Solution 2.2

Method: EM waves and the spectrum

Worked steps

3.0×10^{8} m s^{-1} B1.

Practice 2.3 ▪ 1 mark

State the wavelength range of **visible** light.

Solution 2.3

Method: EM waves and the spectrum

Worked steps

400 nm to 700 nm (B1).

Practice 2.4 ▪ 1 mark

Put these in order of **increasing frequency**: X-rays, radio waves, visible light.

Solution 2.4

Method: EM waves and the spectrum

Worked steps

radio waves $<$ visible light $<$ X-rays B1.

Exam-style 3.1 ▪ 1 mark

Which EM wave has the **shortest** wavelength?

A radio waves

B infrared

C ultraviolet

D γ-rays

Solution 3.1

A radio waves

B infrared

C ultraviolet

D γ-rays ✓

Worked steps

D — γ-rays.

Exam-style 3.2 ▪ 2 marks

A radio wave has frequency 100 MHz. Find its wavelength. ($c = 3.0 \times 10^8$ m s^{-1}.)

Solution 3.2

Method: EM waves and the spectrum

Worked steps

$\lambda = c/f = (3.0 \times 10^8)/(100 \times 10^6)$ M1 $= 3.0$ m A1.

Exam-style 3.3 ▪ 3 marks

A surveyor points a laser rangefinder at the far wall of a valley. The reflected pulse returns $8.4\ \mu$s after it was sent. **Determine** the width of the valley, and **state** the assumption you make about the path of the light.

Solution 3.3

Worked steps

The pulse covers the width **twice**: $d_{\text{total}} = ct = 3.0 \times 10^8 \times 8.4 \times 10^{-6} = 2520$ m (M1); width $= \frac{1}{2} \times 2520 = 1.3 \times 10^3$ m (A1). Assumption: the light travels in a straight line at 3.0×10^8 m s^{-1} through the air, i.e. air is treated as a vacuum (B1).

Exam-style 3.4 ▪ 2 marks

State whether **infrared** or **ultraviolet** has the higher frequency, and explain using the spectrum.

Solution 3.4

Method: EM waves and the spectrum

Worked steps

Ultraviolet has the higher frequency B1; on the spectrum UV is **closer to the high-frequency end** (shorter wavelength) than infrared B1.