

Exercise walk-through

3.4

Sound

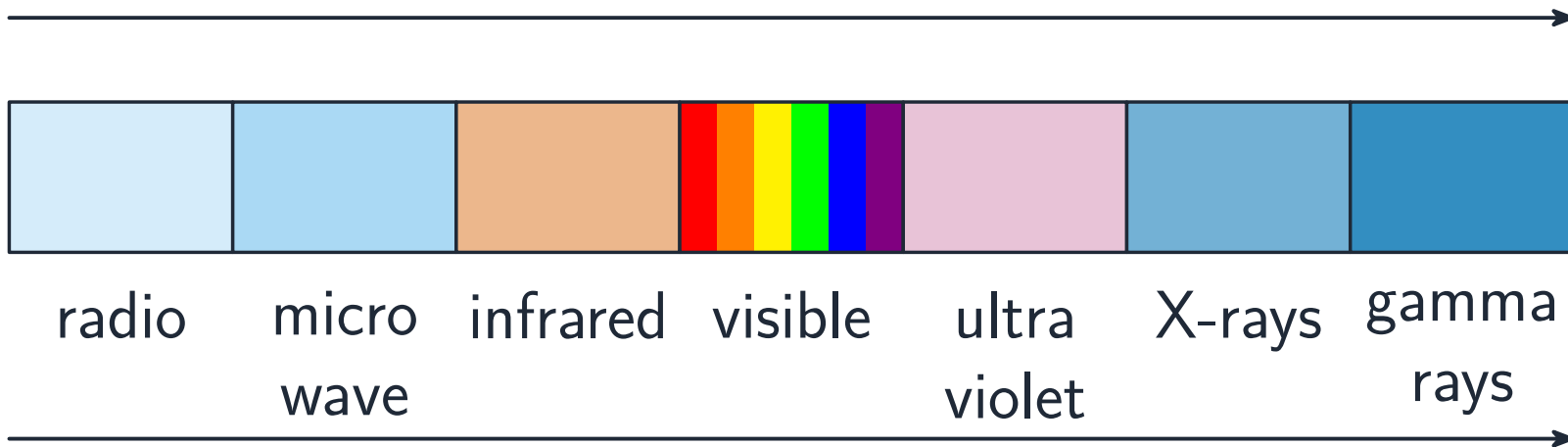
IGCSE Physics

The electromagnetic spectrum

All travel at 3.0×10^8 m/s in a vacuum.

Radio → gamma: frequency & energy **rise**, wavelength **falls**.

wavelength gets shorter



The spectrum: one use and one danger each

radio waves	broadcasting and communications – little known danger at normal intensity
microwaves	mobile phones, satellite TV, cooking – heating of body cells
infrared	remote controls, thermal imaging, grills – skin burns
visible light	seeing, optical fibres, photography
ultraviolet	sterilising water, checking bank notes – skin cancer and eye damage
X-rays X gamma and	medical and security scans; sterilising equipment and treating cancer – cell damage and mutation

All travel at the same speed in a vacuum. Frequency rises left to right, and so does the danger – which is not a coincidence: higher frequency means more energy per photon.

Two more words the spectrum needs

Gamma rays

Gamma rays : shortest wavelength, highest energy. Used for sterilising equipment and treating cancer – and they can cause mutation of cells.

Monochromatic

Light of a single frequency – one pure colour – is **monochromatic**. A laser is; a filament lamp is not.

One family

All of it travels at the same speed in a vacuum; only the wavelength and frequency change along the spectrum.

Order the spectrum by wavelength once and the uses and dangers follow: shorter wavelength, higher energy, greater hazard.

Try it: recover a message after noise

A microphone produces an **analogue** signal that varies continuously. The sound can instead be encoded as **digital** data using two signal levels, 0 and 1.

In this simplified receiver, values below 0.5 are read as 0; values above 0.5 are read as 1. Received levels are:

0.12 0.86 0.73 0.19

Write the four recovered digits and the clean levels the receiver should send on.

If noise changes the third received level to 0.41, will the same rule still recover the original digit? Explain.

Regeneration restores levels when decisions are correct

Received level	0.12	0.86	0.73	0.19
Decision	0	1	1	0
Regenerated level	0	1	1	0

The receiver decides low or high, then sends a fresh signal at the clean level. Small variations are removed rather than passed along to the next stage.

But 0.41 is below the decision boundary: the receiver sends 0 instead of the original 1. Regeneration alone cannot identify that mistake.

Regeneration restores clean levels if each digit is read correctly. Excessive noise can cause a wrong digit.

Exercises 2.1-3.1

2.1 State why sound cannot travel through a vacuum.

[1]

2.2 State the approximate range of frequencies a human can hear.

[1]

3.1 Sound is a:

[1]

☐

- A** transverse wave that needs no medium
- B** longitudinal wave that needs a medium
- C** transverse wave that needs a medium
- D** longitudinal wave that needs no medium

Exercises 2.1-3.1

2.1 State why sound cannot travel through a vacuum.

[1]

2.1

- sound needs a medium (particles) to travel through, and a vacuum has none

2.2 State the approximate range of frequencies a human can hear.

[1]

2.2

- about 20 Hz to 20 000 Hz

3.1 Sound is a:

[1]

☐

- A** transverse wave that needs no medium
B longitudinal wave that needs a medium
C transverse wave that needs a medium
D longitudinal wave that needs no medium

3.1 B

- sound is a longitudinal wave that needs a medium

Exercise 3.2 (a)

3.2 A person stands 660 m from a cliff and shouts. The echo returns 4.0 s later.

(a) Find the speed of sound.

[3]

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[3]

(a) distance there and back = $2 \times 660 \text{ m} = 1320 \text{ m}$

- $v = s/t$

$$v = \frac{d}{t} = \frac{1320 \text{ m}}{4.0 \text{ s}} = \mathbf{330} \frac{\text{m}}{\text{s}}$$

Exercise 3.2 (b)

3.2 A person stands 660 m from a cliff and shouts. The echo returns 4.0 s later.

(b) State whether sound travels faster or slower in water than in air. [1]

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3.2 A person stands 660 m from a cliff and shouts. The echo returns 4.0 s later.

(b) State whether sound travels faster or slower in water than in air. [1]

(b) faster in water

Exercise 3.3

3.3 Explain why you see lightning before you hear the thunder.

[2]

Exercise 3.3

3.3 Explain why you see lightning before you hear the thunder.

[2]

3.3

- light travels much faster than sound
- so the light from the lightning reaches you almost at once, while the sound takes longer to arrive