A-LEVEL PHYSICS • EXERCISE SHEET

8.2 Diffraction

Name: ____________ Class: ________ Date: __________ **Total: 23 marks**

KEY WORDS diffraction 衍射 • wavelength 波长 • obstacle 障碍物 • wave 波

Objective

Build the skills to answer exam questions on **diffraction 衍射** — what it is and how it depends on the gap width.

You must be able to:

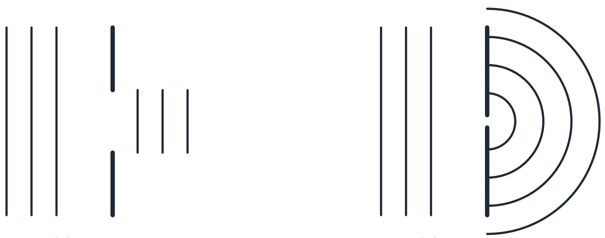
- explain **diffraction** and where it occurs
- describe how the **gap width** relative to the **wavelength** changes the spreading

1 Worked examples

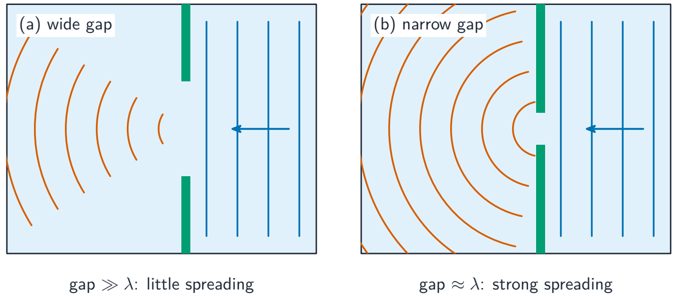
Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ Diffraction

Diffraction is the **spreading** of a wave as it passes through a gap or around an obstacle. **All** waves diffract. The spreading depends on the **gap width compared with the wavelength**:



(a) wide gap (b) narrow gap



Diffraction of waves through a gap

- gap **much wider** than $\lambda \to$ little spreading;
- gap **about** $\lambda \to$ strong spreading.

This is why you can **hear** around a corner (sound $\lambda \approx 1$ m, near a doorway's width) but cannot **see** around it (light $\lambda \approx 500$ nm, far smaller). The wavelength and speed are **unchanged** by diffraction.

2 Practice

Now apply the methods above.

2.1 Define **diffraction**. [1]

2.2 State what happens to the amount of diffraction as a gap is made **narrower** (towards the size of λ). [1]

2.3 State why you can **hear** but not **see** around a corner. [2]

2.4 State which kinds of wave can **diffract**. [1]

3 Exam-style questions

3.1 Noticeable diffraction occurs when the gap width is: [1]

- **A** much larger than the wavelength
- **B** about the same as the wavelength
- **C** exactly zero
- **D** a thousand times the wavelength

3.2 Explain, using diffraction, why **sound** passes through a doorway and spreads into the room, but **light** does not noticeably spread. [3]

3.3 Describe a **ripple-tank** experiment to show that diffraction depends on the gap width. [3]

3.4 State the effect of diffraction on the **wavelength** and **speed** of the wave. [1]

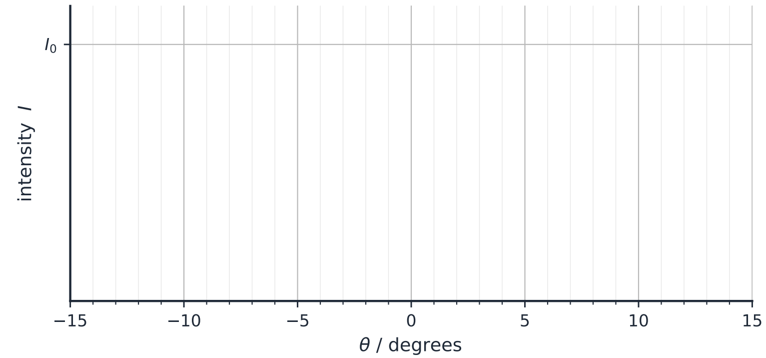
3.5 A parallel beam of light of wavelength 540 nm falls normally on a diffraction grating whose lines are 5.0×10^{-6} m apart. The grating sits at the centre of a circular screen, and the central bright fringe forms at $\theta = 0$ with intensity I_0.

(a) **State** what is meant by the **diffraction** of a wave. [2]

(b) **Show that** the first-order bright fringe forms at $\theta = 6.2°$. [2]

(c) **Determine** the angle at which the **second-order** fringe forms. [1]

(d) On the axes below, **sketch** how the intensity I varies with θ between $-15°$ and $+15°$. [3]



(e) A polarising filter is now placed in the beam **before** the grating. **Suggest** how the pattern on the screen changes. [2]

Solutions

Each answer shows the steps, then the **result**.

2.1

- the **spreading** of a wave as it passes through a gap or around an obstacle

2.2

- the diffraction (spreading) **increases**

2.3

- sound has λ **close to** the doorway, so it diffracts a lot
- light's λ is **far smaller** than the gap, so it diffracts negligibly

2.4

- **all** waves (water, sound, light, microwaves, …)

3.1 B

- diffraction is only noticeable when the gap $\approx \lambda$
- **A** / **D**: a much wider gap lets the wave through almost unspread

3.2

- sound's λ is **similar** to the doorway width, so it diffracts strongly into the room
- light's λ is **much smaller**, so its diffraction is negligible

3.3

- send straight water waves at a barrier with a gap
- observe how much they spread after the gap
- make the gap narrower: the waves spread **more**

3.4

- both the **wavelength** and the **speed** are **unchanged**

3.5

(a) a wave passing through a **gap** (or round an edge) **spreads out** into the region beyond

(b) $n\lambda = d \sin\theta$ with $n = 1$

$$\sin\theta = \frac{540 \times 10^{-9}\ \text{m}}{5.0 \times 10^{-6}\ \text{m}} = 0.108 \Rightarrow \theta = \mathbf{6.2}^\circ$$

(c)

$$\sin\theta = \frac{2 \times 540 \times 10^{-9}\ \text{m}}{5.0 \times 10^{-6}\ \text{m}} = 0.216 \Rightarrow \theta = \mathbf{12}^\circ$$

(d) maxima at $\theta = 0$, $\pm 6.2^\circ$ and $\pm 12^\circ$

- intensity **zero** between them — separated peaks, not a continuous curve
- central peak intensity I_0; outer peaks $\leq I_0$

(e) the maxima stay at the **same angles** (filter changes neither λ nor d)

- every peak is **less intense** (the filter removes the perpendicular polarisation; unpolarised light roughly halves)