

8 Superposition – Part 1

Name: _____ Class: _____ Date: _____

Vocabulary 词汇

Write each word three times. 把每个单词抄写三遍。

English	中文	Write it 3 times (English)		
superposition	叠加	_____	_____	_____
interference	干涉	_____	_____	_____
constructive interference	相长干涉	_____	_____	_____
destructive interference	相消干涉	_____	_____	_____
coherent	相干	_____	_____	_____
path difference	路程差	_____	_____	_____
stationary wave	驻波	_____	_____	_____
node	波节	_____	_____	_____
antinode	波腹	_____	_____	_____
diffraction	衍射	_____	_____	_____
diffraction grating	衍射光栅	_____	_____	_____

Recall

At IGCSE you saw waves reflect and overlap. Bring this with you:

- A wave has amplitude, wavelength and frequency.
- Two waves can be in the same place at the same time.

At AS we look at what happens when waves meet — this is superposition, the idea behind everything from noise-cancelling headphones to the colours in a soap bubble.

New ideas

Read these first. Each idea has a short worked example. Then do the Practice.

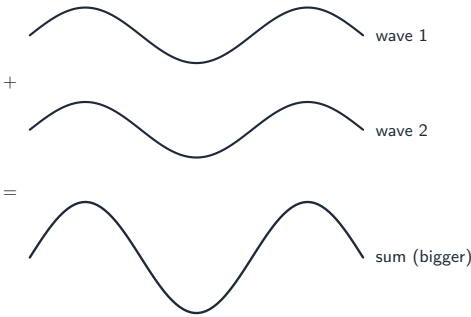
■ 1 Superposition and interference

When two waves meet, their displacements add — this is **superposition** 叠加. The result is called **interference** 干涉:

- waves arriving in step → **constructive interference** 相长干涉 (bigger amplitude);
- waves arriving exactly out of step → **destructive interference** 相消干涉 (they cancel).

For two waves from **coherent** 相干 sources (same frequency, steady phase), what decides the result is the **path difference** 路程差 — the extra distance one wave travels:

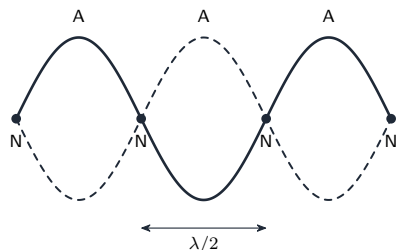
- a whole number of wavelengths ($0, \lambda, 2\lambda, \dots$) → constructive;
- an odd number of half-wavelengths ($\frac{1}{2}\lambda, \frac{3}{2}\lambda, \dots$) → destructive.



Worked example. Two waves of amplitude 2 mm arriving in step add to 4 mm (constructive); arriving exactly out of step they cancel to 0 (destructive).

■ 2 Stationary waves

A **stationary wave** 驻波 forms when two identical waves travel in opposite directions (for example a wave and its reflection). It does not move along.



It has **node** 波节 points (no movement) and **antinode** 波腹 points (largest movement) that stay in fixed places. Neighbouring nodes are half a wavelength apart.

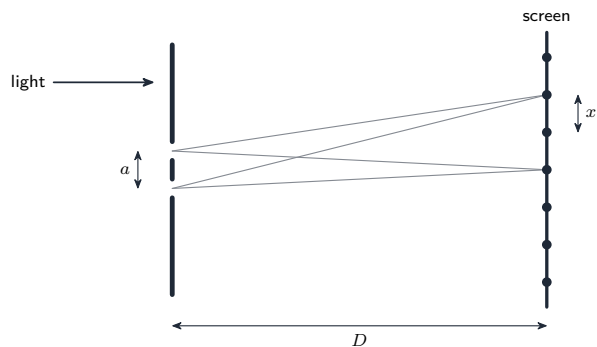
Worked example. If neighbouring nodes are 0.30 m apart, then $\frac{1}{2}\lambda = 0.30$ m, so $\lambda = 0.60$ m.

■ 3 Two-source interference

When light passes through two narrow slits it spreads out (**diffraction** 衍射) and the two beams interfere, making bright and dark bands on a screen. The bright-band spacing is

$$x = \frac{\lambda D}{a},$$

where a is the slit separation and D the distance to the screen.



Worked example. For $\lambda = 5.0 \times 10^{-7}$ m, $a = 0.40$ mm, $D = 1.5$ m: $x = \frac{\lambda D}{a} =$

$$\frac{(5.0 \times 10^{-7})(1.5)}{0.40 \times 10^{-3}} = 1.9 \times 10^{-3} \text{ m.}$$

A **diffraction grating** 衍射光栅 (many slits) gives sharp bright lines at angles where $d \sin \theta = n\lambda$.

Watch out: the sources must be **coherent** (same frequency, steady phase) for a steady pattern — two ordinary bulbs will not interfere visibly.

Practice

8.1 Two waves meet exactly in step. Each has amplitude 3 mm. State the type of interference and the resulting amplitude. [2]

8.2 Two coherent waves meet with a path difference of 1.5λ . State whether the interference is constructive or destructive, and why. [2]

8.3 On a stationary wave, neighbouring nodes are 0.40 m apart. Find the wavelength. [1]

8.4 Light of wavelength 6.0×10^{-7} m passes through slits 0.50 mm apart onto a screen 2.0 m away. Find the bright-fringe spacing $x = \frac{\lambda D}{a}$. [3]

8.5 Explain *why* the two slits must be lit by one single source (or a laser), not by two separate lamps. [2]

8.6 Challenge. In the two-slit experiment, state and explain what happens to the fringe spacing if the slits are moved *closer together*. ^[2]
