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.

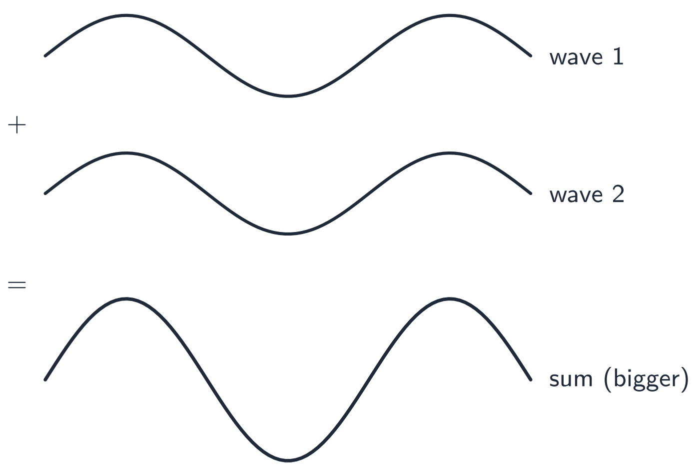
1 Superposition and interference

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:

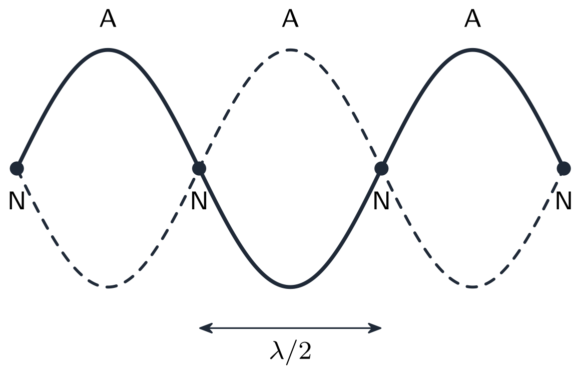
- a whole number of wavelengths $(0, \lambda, 2\lambda, \dots)$ → constructive;
- an odd number of half-wavelengths $(\frac{1}{2}\lambda, \frac{3}{2}\lambda, \dots)$ → destructive.



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.

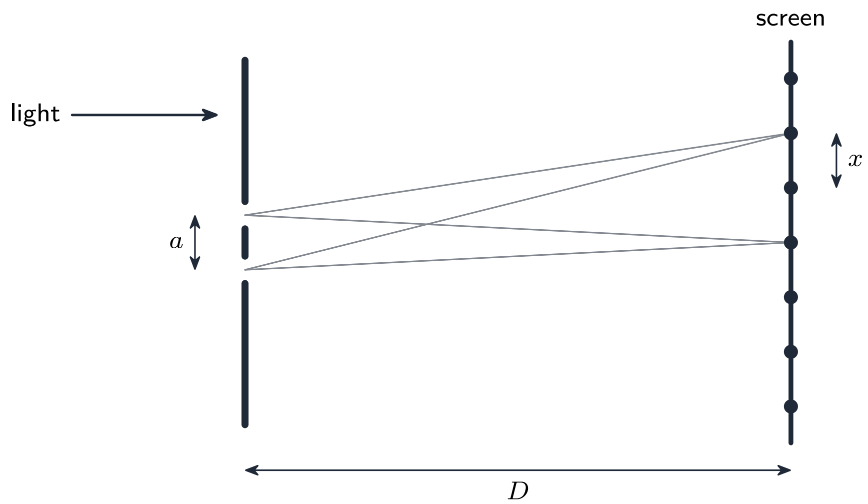
Worked example. If neighbouring nodes are 0.30 m apart, then $\frac{1}{2}\lambda = 0.30$ m, so $\lambda = 0.60$ m.

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: $x = \dfrac{\lambda D}{a} =$

$$\frac{(5.0\times10^{-7})(1.5)}{0.40\times10^{-3}} = 1.9\times10^{-3}\ \text{m}.$$

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 $x = \dfrac{\lambda D}{a}$. [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]