8 Superposition – Part 1

Name: _____ Class: _____ Date: _____

Vocabulary

Write each word three times.

English	**Write it 3 times** (English)		
superposition			
interference			
constructive interference			
destructive interference			
coherent			
path difference			
stationary wave			
node			
antinode			
diffraction			
diffraction grating			

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.

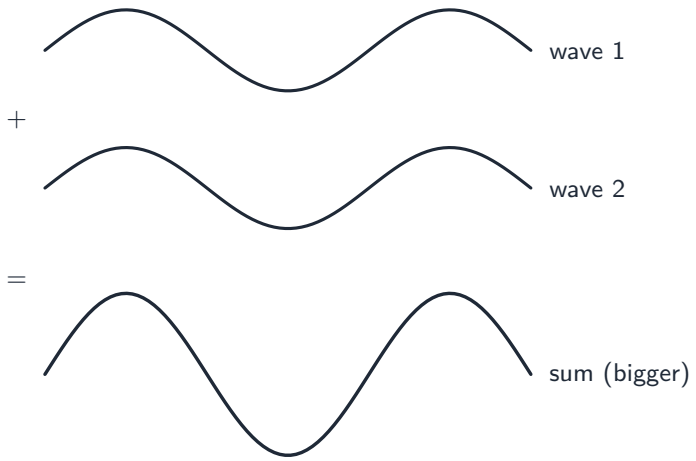
1 Superposition and interference

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

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

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

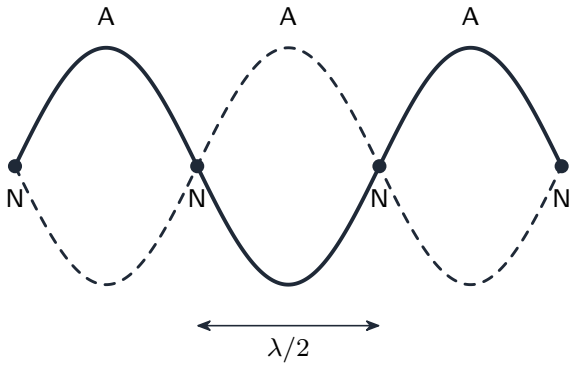
- a whole number of wavelengths $(0, \lambda, 2\lambda, \dots)$ → constructive;
- an odd number of half-wavelengths $(\frac{1}{2}\lambda, \frac{3}{2}\lambda, \dots)$ → destructive.



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



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

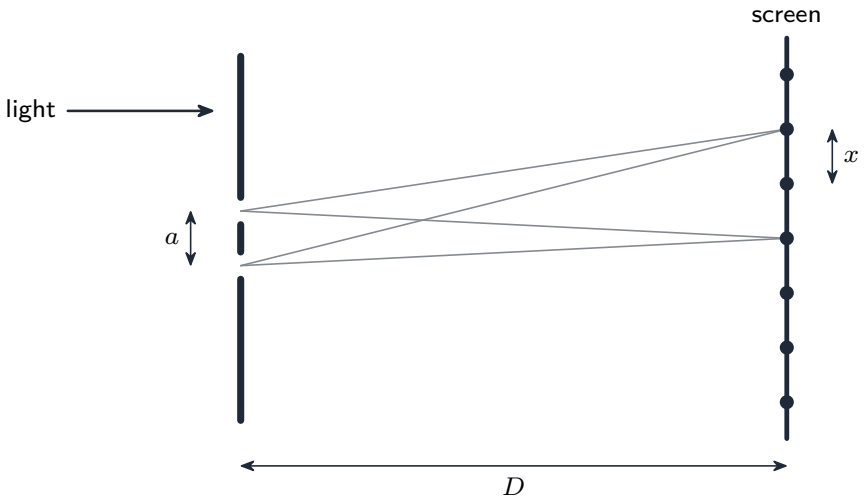
Worked example. If neighbouring nodes are 0.30 m apart, then $\frac{1}{2}\lambda = 0.30$ m, so $\lambda = 0.60$ m.

3 Two-source interference

When light passes through two narrow slits it spreads out (**diffraction**) 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: $x = \dfrac{\lambda D}{a} = \dfrac{(5.0 \times 10^{-7})(1.5)}{0.40 \times 10^{-3}} = 1.9 \times 10^{-3}$ m.

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

exercises.lol exercises.com.cn

> **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]