8 Superposition – Part 2

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)		
Intensity	强度			
fundamental	基频			
resonance tube	共鸣管			
normal	法线			
slit spacing	缝间距			
order	级次			

Recall

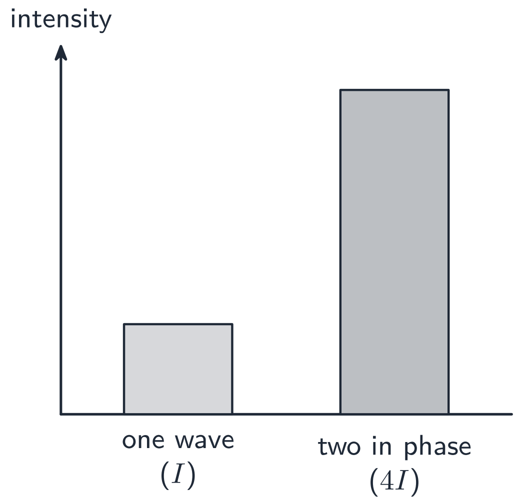
In **Part 1** you used superposition, constructive and destructive interference, path difference, stationary waves (nodes and antinodes), and the double-slit fringe spacing $x = \lambda D/a$. Part 2 adds intensity in interference, stationary waves in strings and pipes, and the diffraction grating.

New ideas

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

■ 1 Intensity in interference

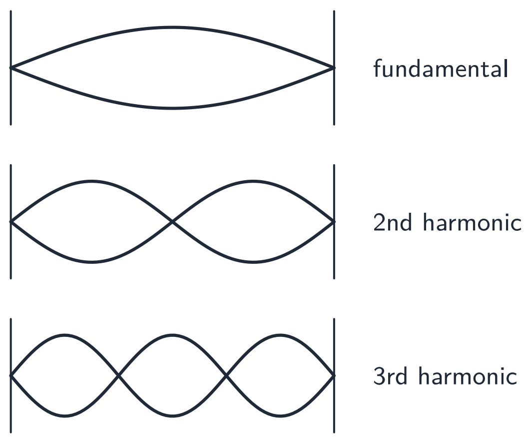
Intensity 强度 goes as the square of the amplitude, $I \propto A^2$. So when two equal waves meet **in phase**, the amplitude is $2A$ and the intensity is $(2A)^2 = 4A^2$ — **four times** the intensity of one wave alone (not twice).



Worked example. If one wave alone gives an intensity of 5 W m^{-2}, two equal waves in phase give $4 \times 5 = 20$ W m^{-2}.

■ 2 Stationary waves in strings and pipes

- A string fixed at both ends vibrates with a node at each end. The **fundamental** 基频 (lowest note) is a single loop, so $L = \frac{1}{2}\lambda$.
- A **resonance tube** 共鸣管 closed at one end has a node at the closed end and an antinode at the open end, so its fundamental has $L = \frac{1}{4}\lambda$. A tube open at both ends has $L = \frac{1}{2}\lambda$.



Worked example. A guitar string 0.65 m long sounds its fundamental, so $L = \frac{1}{2}\lambda$ and $\lambda = 1.3$ m.

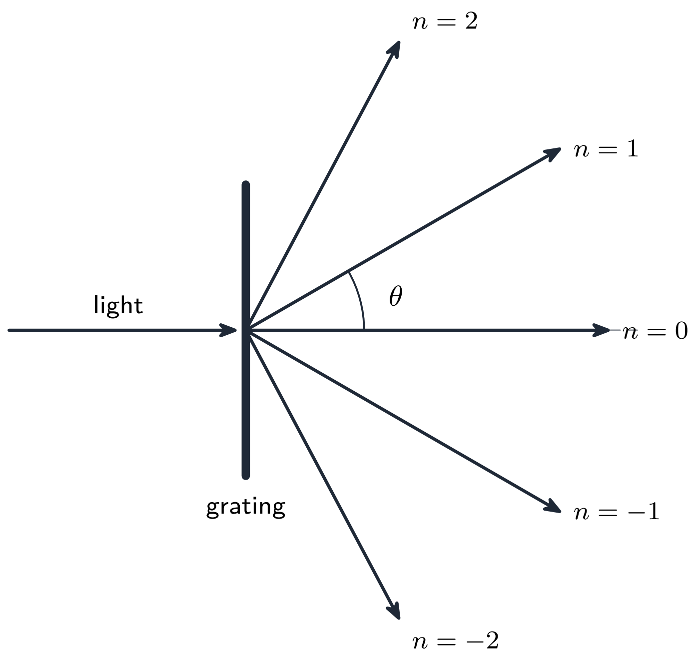
Watch out: a closed pipe fits only a *quarter* wavelength in its fundamental ($L = \frac{1}{4}\lambda$), but a string or open pipe fits a *half* ($L = \frac{1}{2}\lambda$) — check which one you have.

3 The diffraction grating

A diffraction grating has many equally spaced slits. Bright maxima appear at angle θ from the **normal** 法线 where

$$d \sin\theta = n\lambda,$$

with d the **slit spacing** 缝间距 and n the **order** 级次 $(0, 1, 2, \ldots)$. More slits make the maxima much sharper than a double slit.



Worked example. A grating with 500 lines per mm ($d = 2.0 \times 10^{-6}$ m) with light of 600 nm: $\sin\theta = \dfrac{n\lambda}{d} = \dfrac{600 \times 10^{-9}}{2.0 \times 10^{-6}} = 0.30$, so $\theta \approx 17^\circ$ for $n = 1$.

Practice

8.1 Two waves of equal amplitude meet exactly in phase. State the factor by which the intensity is greater than that of one wave alone. [1]

8.2 A string fixed at both ends vibrates in its fundamental mode with the loop 0.60 m long. Find the wavelength. [1]

8.3 A tube closed at one end has its fundamental when its length is 0.25 m. Find the wavelength of the sound. [2]

8.4 A grating with 300 lines per mm is lit normally by light of wavelength 500 nm. Find the angle of the first-order ($n = 1$) maximum. [3]

8.5 A grating has 400 lines per mm. Find the slit spacing d in metres. [1]

8.6 Explain *why* two equal waves meeting in phase give *four* times the intensity of one, not twice. [2]

8.7 Challenge. A grating gives a first-order maximum where $\sin\theta_1 = 0.30$. Find the angle of the second-order ($n = 2$) maximum for the same light. [2]