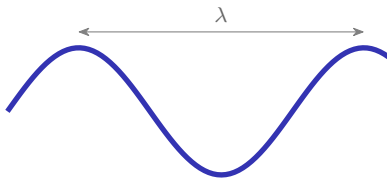


Waves, Sound, and Physical Optics

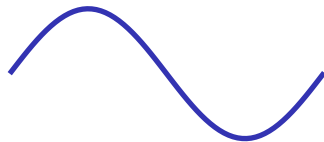
AP Physics 2 ■ Unit 14

AP Physics 2



What we will cover

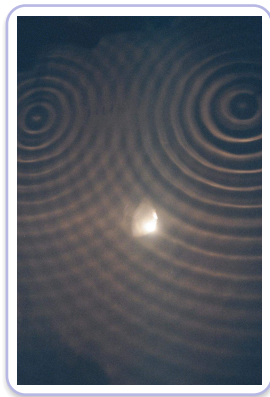
- 1 Wave types and properties
- 2 Periodic waves
- 3 Polarization
- 4 The electromagnetic spectrum
- 5 The Doppler effect
- 6 Interference and standing waves
- 7 Diffraction and the double slit



Wave types

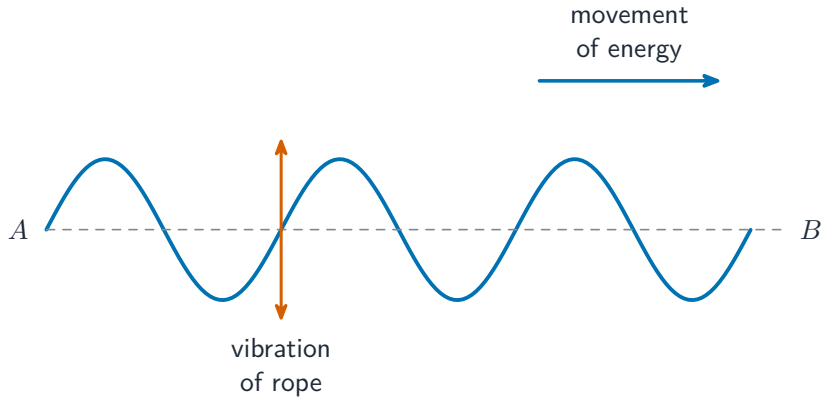
A **wave** 波 carries **energy**, not matter – the medium jiggles in place.

- **transverse** 横波: medium moves **across** the travel (string, light)
- **longitudinal** 纵波: medium moves **along** it, in compressions (sound)



*Waves superpose
to reinforce or cancel*

Wave types



Periodic waves and polarization

The wave equation

$$v = f\lambda, \quad f = \frac{1}{T}$$

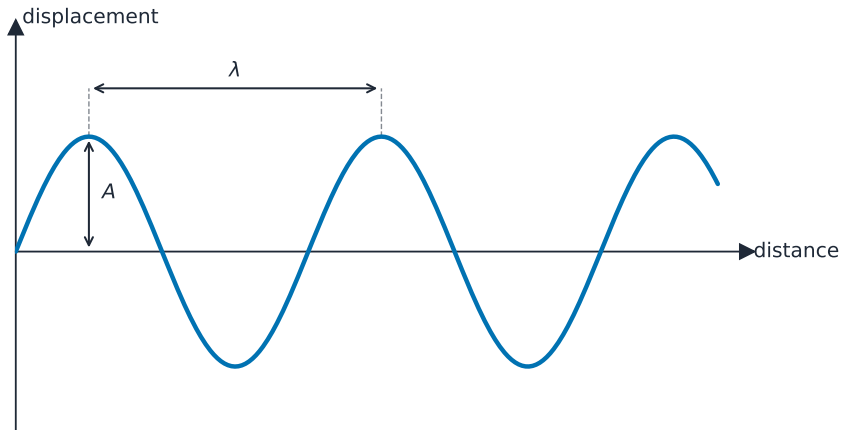
Speed is set by the **medium**: raise f and λ shrinks.

170 Hz at 340 m/s: $\lambda = 2$ m.

Polarization 偏振 works only on **transverse** waves – a filter passes one plane of vibration. Sound cannot be polarized.

Reflecting off a denser medium flips a wave over (inverted).

Periodic waves and polarization



The electromagnetic spectrum

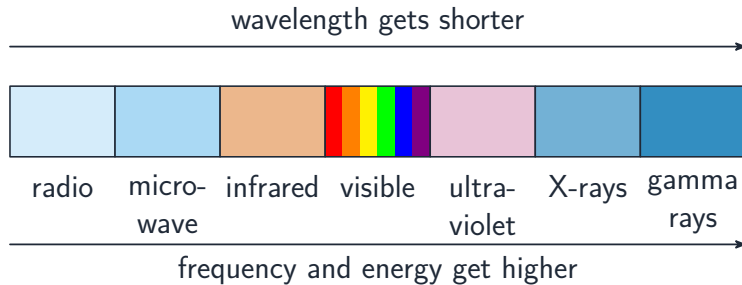
An **electromagnetic wave** 电磁波 is oscillating E and B fields – no medium needed.

All travel at $c = 3 \times 10^8$ m/s; they differ only in frequency.



*Diffraction
reveals the wave nature of light*

The electromagnetic spectrum

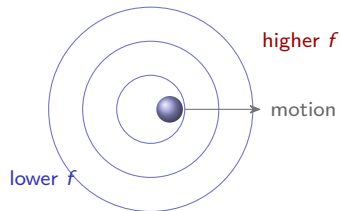


The Doppler effect

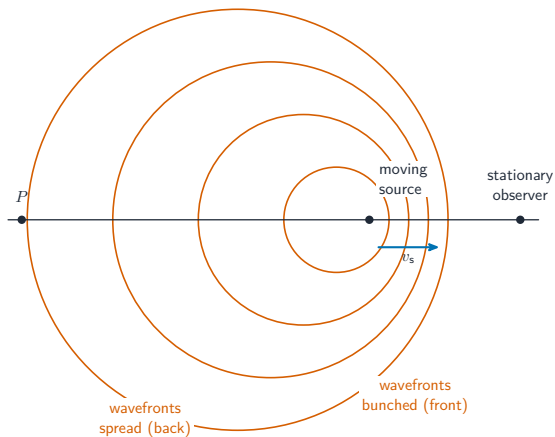
The **Doppler effect** 多普勒效应: the observed frequency shifts when source and observer move relatively.

- approaching $\Rightarrow$ bunched up, **higher** pitch
- receding $\Rightarrow$ stretched, **lower** pitch

The **redshift** 红移 of galaxies is Doppler proof the universe expands.



The Doppler effect

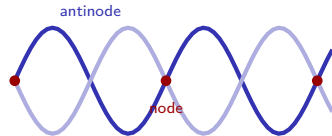


Interference and standing waves

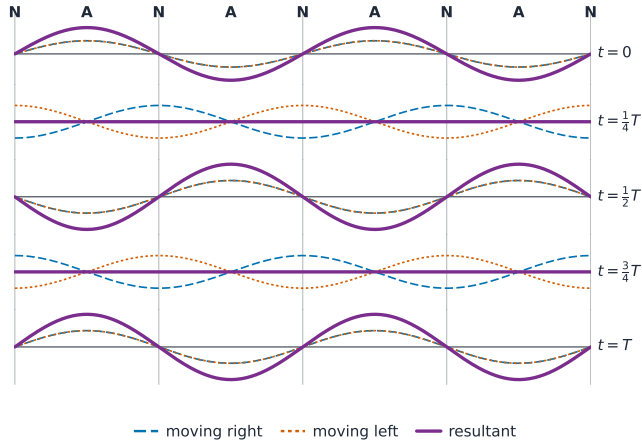
Overlapping waves add point by point
(**superposition** 叠加原理):

- **constructive** 相长干涉: crest + crest
⇒ bigger
- **destructive** 相消干涉: crest + trough
⇒ cancel

A **standing wave** 驻波 has fixed **nodes** 波节 and **antinodes** 波腹 – only certain wavelengths fit (musical notes).



Interference and standing waves



Diffraction and the double slit

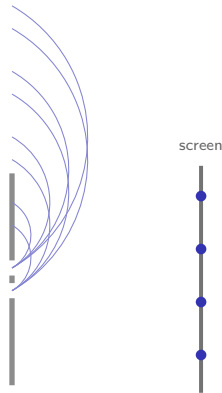
Diffraction 衍射: waves spread through gaps and around obstacles – most when the gap $\approx \lambda$.

Young's double slit – bright fringes

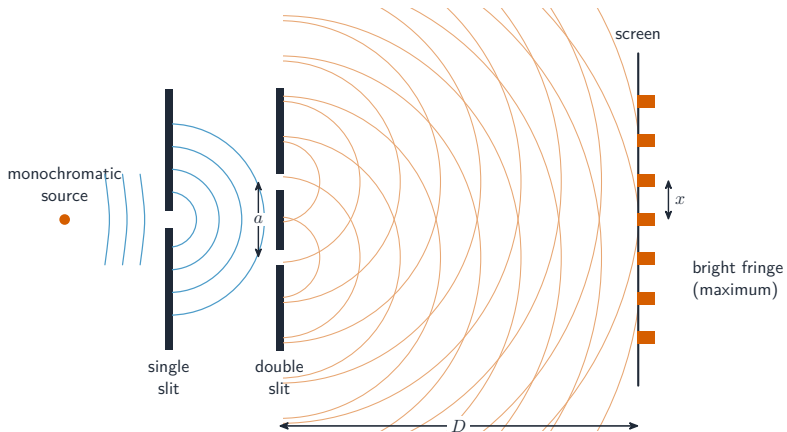
$$d \sin \theta = m \lambda$$

A **grating** 衍射光栅 (many slits) sharpens them into thin lines.

Thin-film 薄膜干涉 interference colours soap bubbles and oil slicks.



Diffraction and the double slit



Unit 14 – key takeaways

1 Waves

$v = f\lambda$; transverse vs longitudinal;
only transverse polarize

2 EM spectrum

all travel at c ; differ only in frequency

3 Doppler

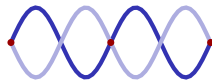
approach raises pitch; redshift
shows expansion

4 Interference

standing-wave nodes; $d \sin \theta = m\lambda$ for the double slit

Check yourself

- 1 Double a wave's frequency in the same medium – what happens to λ ?
- 2 Can sound be polarized?
- 3 A siren speeds toward you – higher or lower pitch?
- 4 What is a point that never moves on a standing wave called?



Answers 1. it halves 2. no 3. higher 4. a node