

Exercise walk-through

14.8

Double-Slit Interference and Diffraction Gratings

AP Physics 2

Diffraction and the double slit

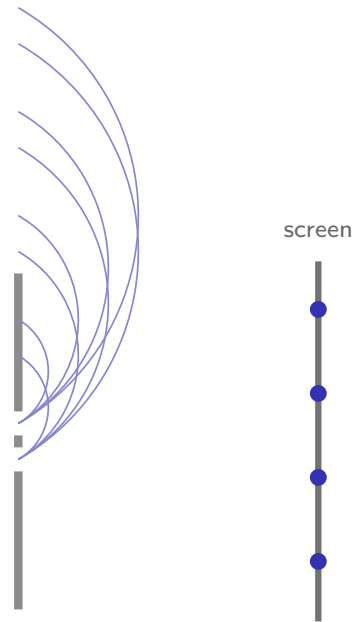
Diffraction : waves spread through gaps and around obstacles – most when the gap $\approx \lambda$.

Young's double slit – bright fringes

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

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

Thin-film interference
colours soap bubbles and oil slicks.



Intensity, and the antireflection coating

intensity

the average power a wave delivers **per unit area** over one period, in W/m^2

through a polarizer

unpolarised light loses **half**; after that, $I = I_0 \cos^2 \theta$

a thin film

light reflecting off its top and bottom surfaces interferes with itself

what decides the colour

the film's thickness and the wavelength – which is why a soap bubble's colours shift as it thins

an antireflection coating

the same physics used deliberately, on camera lenses, glasses and solar cells

how it works

a layer of chosen thickness makes the two reflections **cancel**, so more light is transmitted

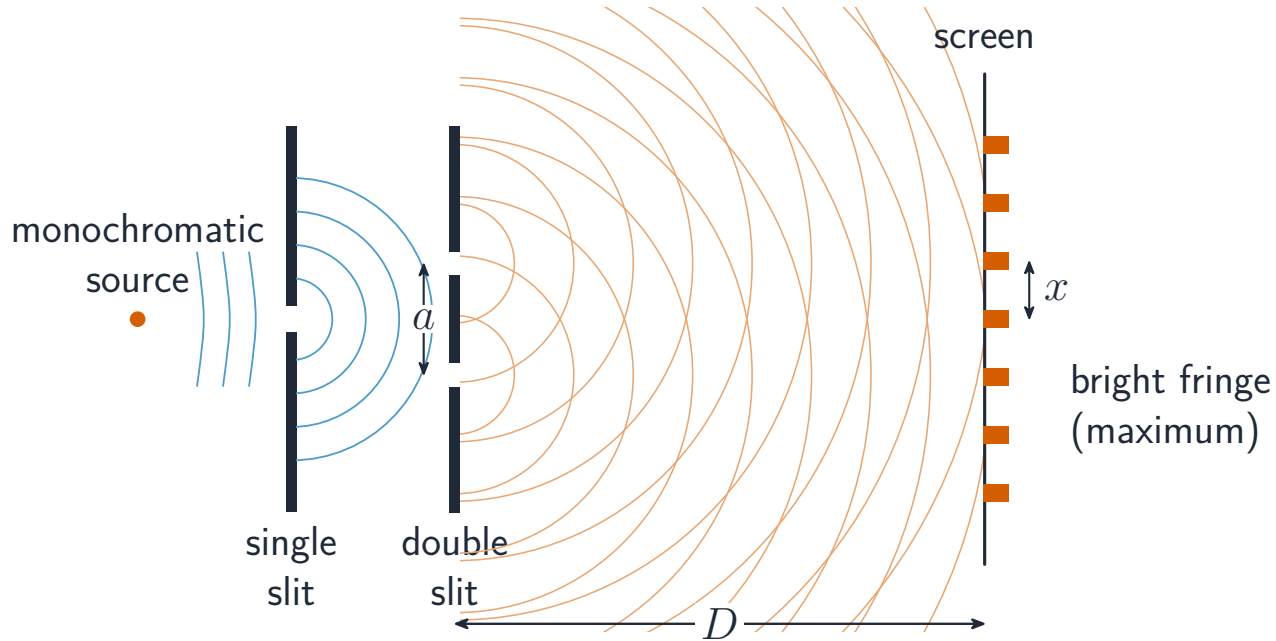
A reflection off a **denser** medium adds a half-wavelength shift. Counting that extra half turns a thin-film question from guesswork into arithmetic.

Describing a periodic wave, and how two waves add

the quantities	wavelength λ , period T , frequency $f = 1/T$, amplitude, and speed $v = f\lambda$
coherent sources	same frequency and a constant phase relationship – the condition for a stable interference pattern
constructive interference	path difference is a whole number of wavelengths; the amplitudes add
destructive interference	path difference is an odd number of half wavelengths; they cancel
beat frequency	$ f_1 - f_2 $ – the slow swell when two close frequencies overlap
what sets v	the medium , not the source – so changing f changes λ

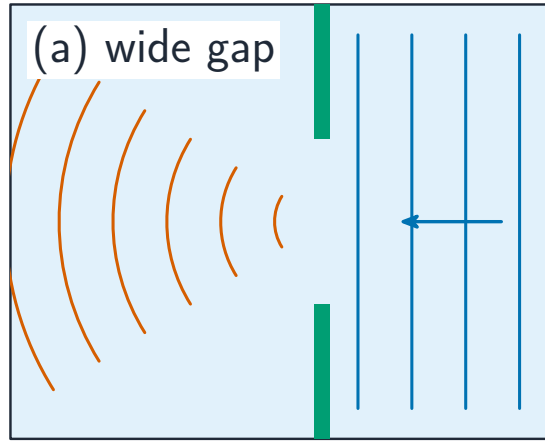
Every interference question reduces to a **path difference in wavelengths**. Work that out first and the constructive/destructive answer follows.

Double-Slit Interference and Diffraction Gratings

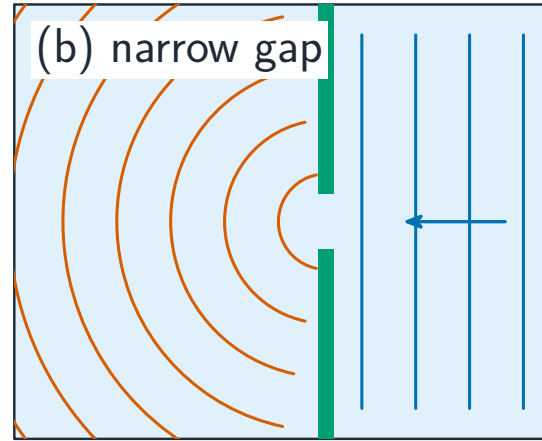


Young's double slits give an interference pattern of bright and dark fringes

Diffraction



gap $\gg \lambda$: little spreading



gap $\approx \lambda$: strong spreading

Waves spread out (diffract) as they pass through a gap

Exercises 2.1-2.3

2.1 State what the double-slit experiment demonstrates about light. [1]

2.2 Write the condition for bright fringes in a double-slit pattern. [1]

2.3 Light of wavelength 600 nm falls on slits 0.20 mm apart. Find the angle to the first bright fringe ($m = 1$). [2]

Exercises 2.1-2.3

2.1 State what the double-slit experiment demonstrates about light. [1]

2.1

- that light behaves as a wave (it interferes)
-

2.2 Write the condition for bright fringes in a double-slit pattern. [1]

2.2

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

2.3 Light of wavelength 600 nm falls on slits 0.20 mm apart. Find the angle to the first bright fringe ($m = 1$). [2]

2.3

- $\sin \theta = \frac{m\lambda}{d} = \frac{600 \times 10^{-9}}{0.20 \times 10^{-3}} = 3.0 \times 10^{-3} \Rightarrow \theta = 0.17^\circ$

Exercises 3.1-3.2

3.1 In a double-slit experiment, bright fringes occur when $d \sin \theta$ equals

[1]

☐

A $m\lambda$

B $(m + \frac{1}{2})\lambda$

C λ/m

D $2m\lambda$

3.2 Compared with a double slit, a diffraction grating gives maxima that are

[1]

☐

A blurrier

B sharper and more widely spaced

C closer together

D absent

Exercises 3.1-3.2

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[1]

- ☐ **A** $m\lambda$
B $(m + \frac{1}{2})\lambda$
C λ/m
D $2m\lambda$

3.1 A

- $m\lambda$.

3.2 Compared with a double slit, a diffraction grating gives maxima that are

[1]

- ☐ **A** blurrier
B sharper and more widely spaced
C closer together
D absent

3.2 B

- sharper and more widely spaced.

Exercise 3.3 (a)

3.3 A grating has 300 lines per millimetre and is lit by light of wavelength 500 nm.

(a) Find the slit spacing d .

[2]

Exercise 3.3 (a)

3.3 A grating has 300 lines per millimetre and is lit by light of wavelength 500 nm.

(a) Find the slit spacing d .

[2]

(a)

- $$d = \frac{1}{300 \times 10^3 \text{ m}^{-1}} = 3.33 \times 10^{-6} \text{ m}$$

Exercise 3.3 (b)

3.3 A grating has 300 lines per millimetre and is lit by light of wavelength 500 nm.

(b) Find the angle to the first-order maximum.

[2]

Exercise 3.3 (b)

3.3 A grating has 300 lines per millimetre and is lit by light of wavelength 500 nm.

(b) Find the angle to the first-order maximum.

[2]

(b)

- $$\sin \theta = \frac{\lambda}{d} = \frac{500 \times 10^{-9}}{3.33 \times 10^{-6}} = 0.15 \Rightarrow \theta = 8.6^\circ$$