CHAPTER 24: WAVE OPTICS

24.1: YOUNG'S DOUBLE-SLIT EXPERIMENT

24.2: REFRACTIVE INDEX, LIGHT SPEED, AND WAVE COHERENCE

24.3 GRATINGS: AN APPLICATION OF INTERFERENCE

24.5 DIFFRACTION OF LIGHT

24.6: RESOLVING POWER

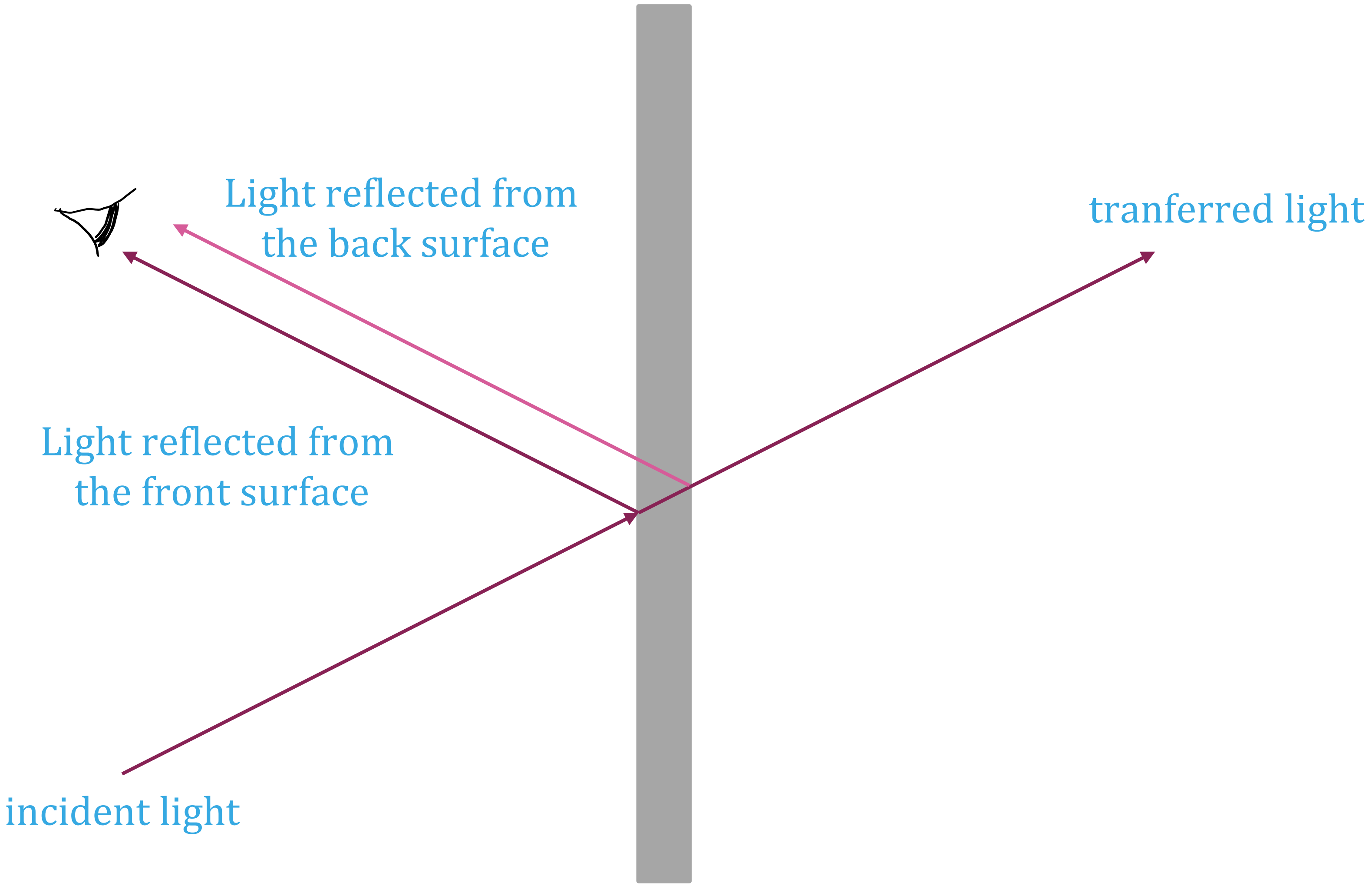
24.7 SKILLS FOR APPLYING THE WAVE MODEL OF LIGHT

24.4 THIN-FILMS INTERFERENCE*

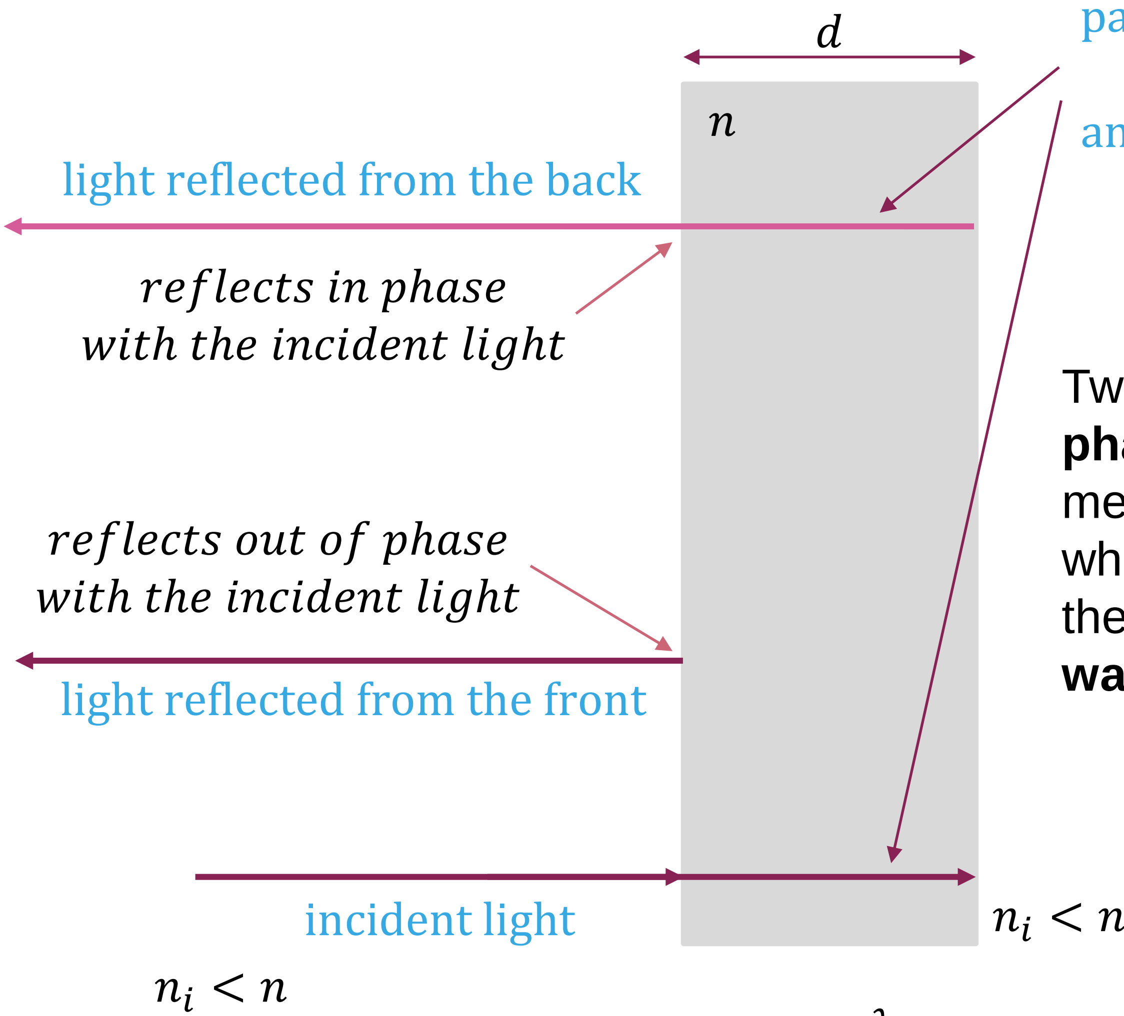
REVIEW

Reflection from boundaries:

24.4 THIN FILM INTERFERENCE



24.4 Thin Film Interference – Free Standing Film



$$\lambda_n = \frac{\lambda}{n}$$

path difference between the light reflected from the front and light reflected from the back

$$\delta = 2d$$

Two reflected beams are **out of phase with each other**, which means they interact constructively when the path difference is equal to the multiplication of **half of the wavelength:**

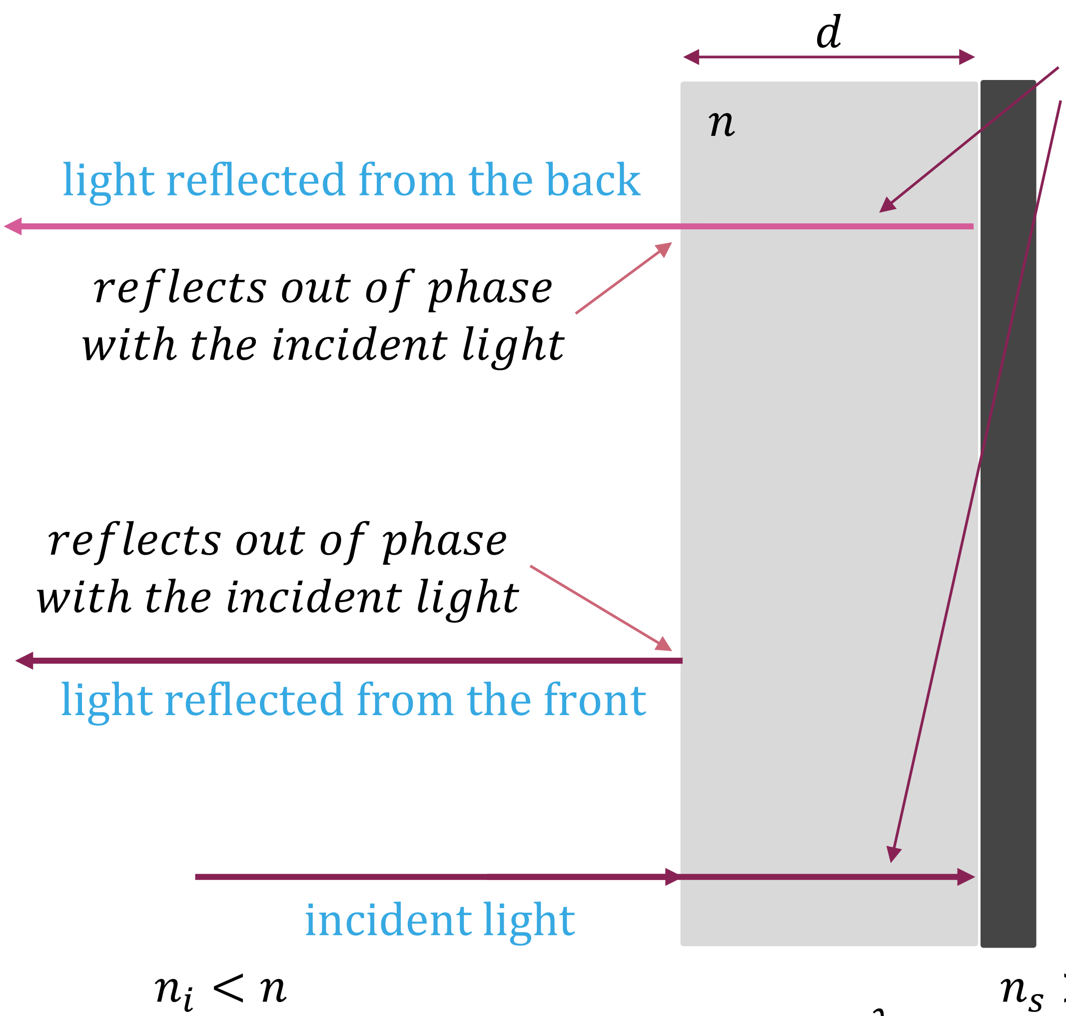
$$2d = \left(m + \frac{1}{2}\right)\lambda_{medium}$$

$$2d = \left(m + \frac{1}{2}\right)\frac{\lambda}{n}$$

$$2nd = \left(m + \frac{1}{2}\right)\lambda$$

$$m = 0,1,2,3, \ldots$$

24.4 Thin Film Interference – Free Standing Film



$$\lambda_n = \frac{\lambda}{n}$$

path difference between the light reflected from the front and light reflected from the back

$$\delta = 2d$$

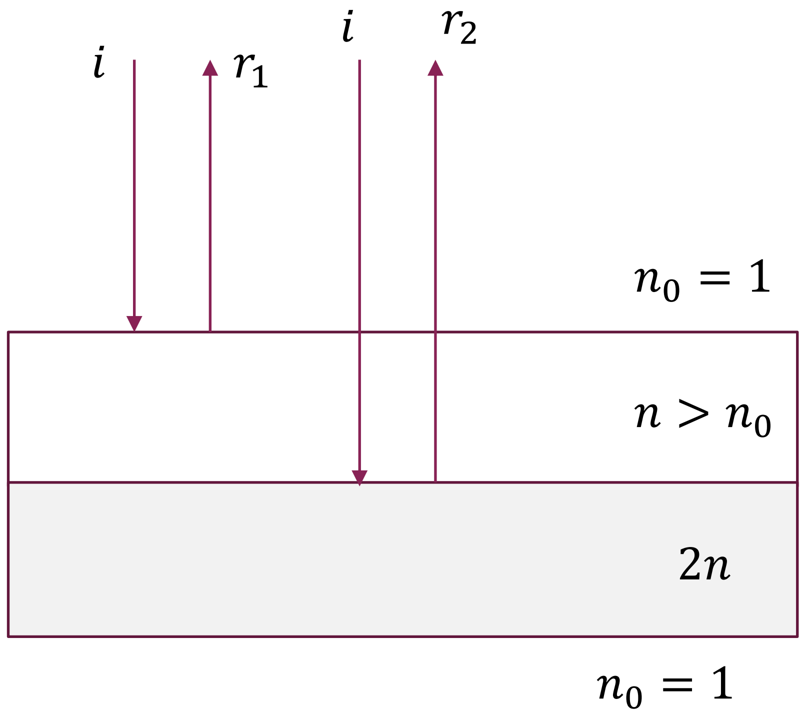
Two reflected beams are **in of phase with each other**, which means they interact constructively when the path difference is equal to the multiplication of **full wavelength:**

$$2d = m\lambda_{medium}$$

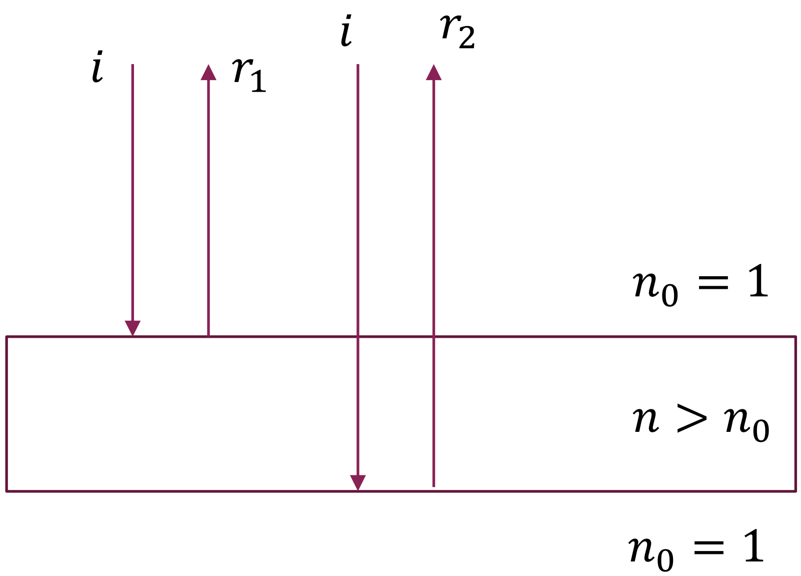
$$2d = m\frac{\lambda}{n}$$

$$2nd = m\lambda$$

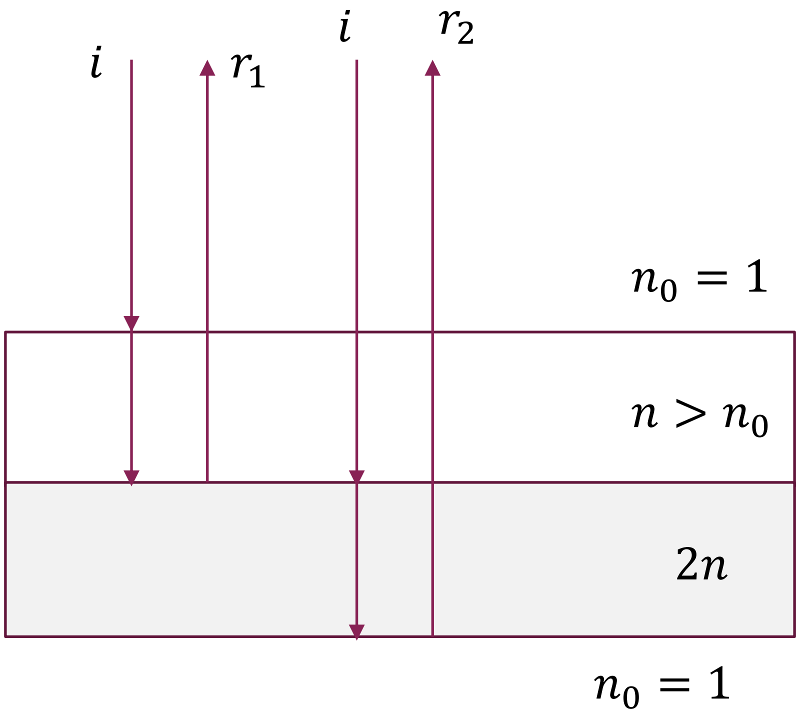
$$m = 0,1,2,3, \ldots$$



i
r_1
i
r_2
$n_0 = 1$
$n > n_0$
$2n$
$n_0 = 1$

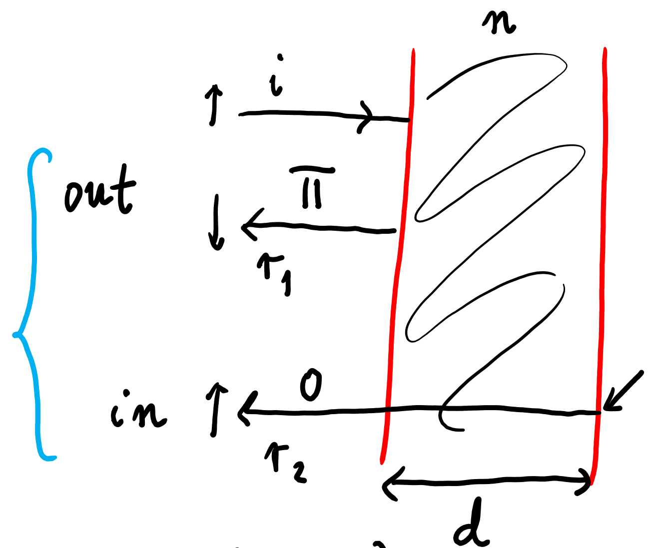


i
r_1
i
r_2
$n_0 = 1$
$n > n_0$
$n_0 = 1$


i
r_1
i
r_2
$n_0 = 1$
$n > n_0$
$2n$
$n_0 = 1$

EXAMPLE 24 F

A soap bubble (n=1.33) floating in air has the shape of a spherical shell with a wall thickness of 120 nm.
What is the wavelength of visible light that is most strongly reflected?



r_1 & r_2 ↓ out of phase

$$2d \cdot n = \left(m + \frac{1}{2}\right)\lambda$$

$$2 \cdot 120\,nm \cdot 1.33 = \left(m + \frac{1}{2}\right)\lambda$$

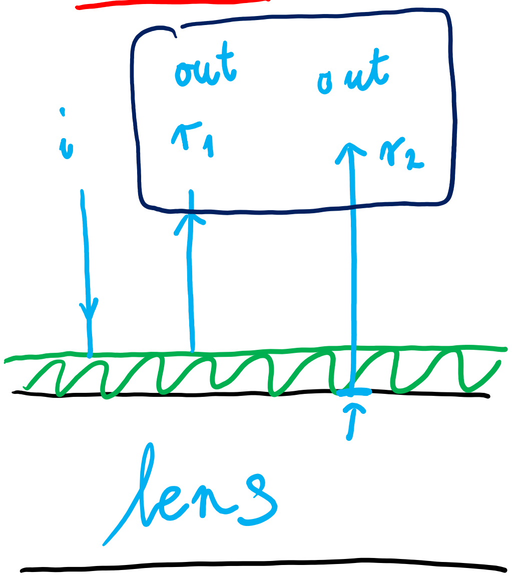
$$320\,nm = \left(m + \frac{1}{2}\right)\lambda$$

$m = 0$: $320\,nm = \frac{1}{2}\lambda \rightarrow \boxed{\lambda = 640\,nm}$

$m = 1.$ $320\,nm = \frac{3}{2}\lambda \rightarrow \lambda = 213\,nm$

EXAMPLE 24 G

A lens coated with a thin layer of material having a refractive index of 1.25 reflects the least amount of light at wavelength of 590 nm. What is the **minimum** thickness of the coating?



destructive!

constructive : $2nd = m\lambda$

→ destructive : $2nd = (m + \frac{1}{2})\lambda$

$m = 0$

$2nd = \frac{1}{2}\lambda$

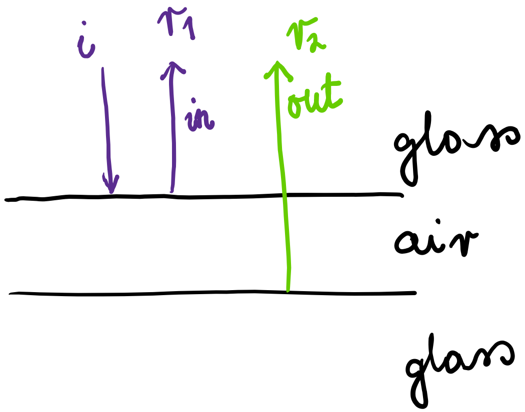
$2 \times 1.25\, d = \frac{1}{2}\, 590\,\text{nm}$

$d = \frac{1}{4} \cdot 590 \cdot \frac{1}{1.25}$

EXAMPLE 24 H

Two flat glass surfaces are separated by a 150 nm gap of air.

What wavelengths of light would be reflected brightly from the gap?



reflective rays out of phase

$$2nd = \left(m + \frac{1}{2}\right)\lambda$$

$m = 0: \; 2d = \frac{1}{2}\lambda \rightarrow \lambda = 2 \cdot 2d = 600\,nm \leftarrow$

$m = 1: \; 2d = 1.5\lambda \rightarrow \lambda = \frac{4}{3}d = 200\,nm$

What is the longest wavelength that would be reflected brightly?

The one for $m = 0$