

Wave Interference

- Thin Films

Refractive Index

The speed of light depends on the material. We define the refractive index "n" as

$$n = (\text{speed of light in vacuum}) / (\text{speed of light in a material})$$

material	refractive index	speed of light
vacuum	1	$c \approx 300,000$ km/s
air	1.0003	
glass	about 1.5	200,000 km/s
water	1.333	225,000 km/s
diamond	2.4	125,000 km/s

Quick Quiz

A beam of yellow light (wavelength 600 nm), travelling in air, passes into a pool of water. What happens to the wavelength and the frequency of the light wave?

- a) Wavelength changes. Frequency stays the same.
- b) Frequency changes. Wavelength stays the same.
- c) Wavelength and frequency both change.
- d) Wavelength and frequency both stay the same.

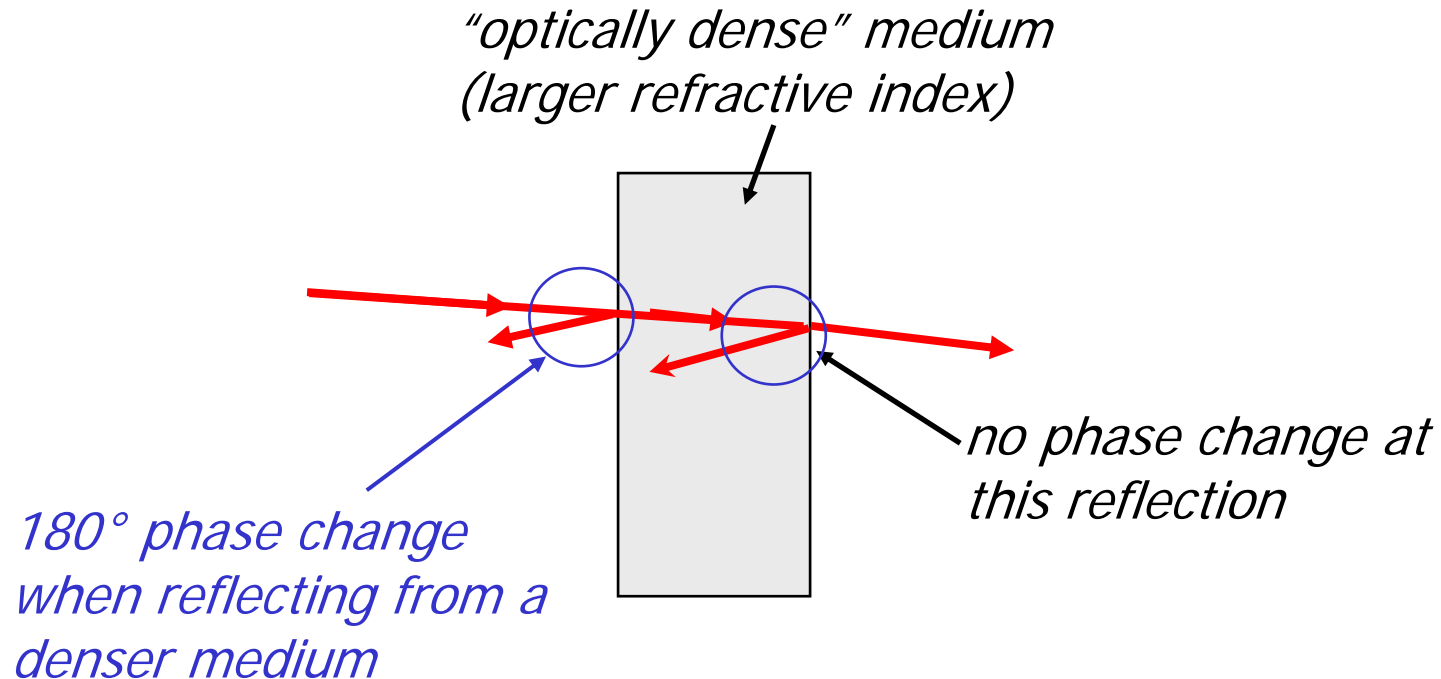
Example

A beam of yellow light (wavelength 600 nm), travelling in air, passes into a pool of water. By what **factor** do the following quantities change as the beam goes from air into water?

- A) speed
- B) frequency
- C) wavelength

Reflection and Phase Change

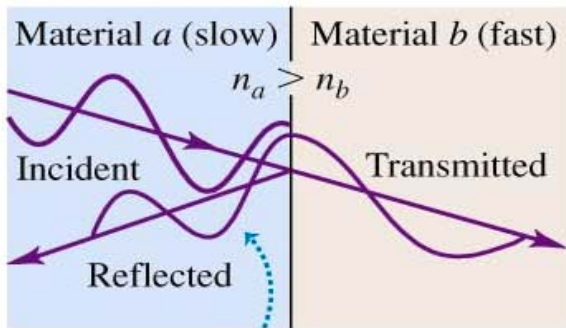
Light waves may have a 180° phase change when they reflect from a boundary:



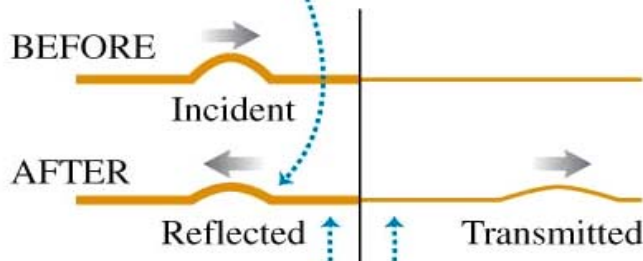
Just remember this : **low to high, phase shift of pi !**

Interference in thin films

(a) If the transmitted wave moves faster than the incident wave ...

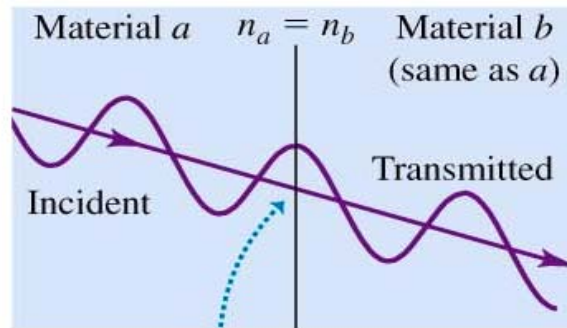


... the reflected wave undergoes no phase change.

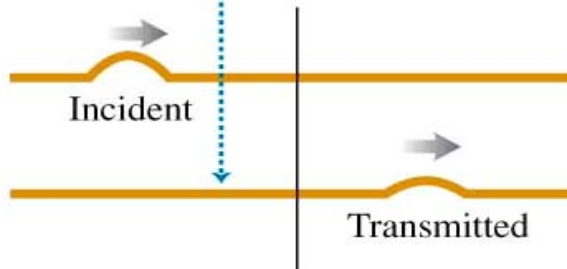


Waves travel slower on thick ropes than on thin ropes.

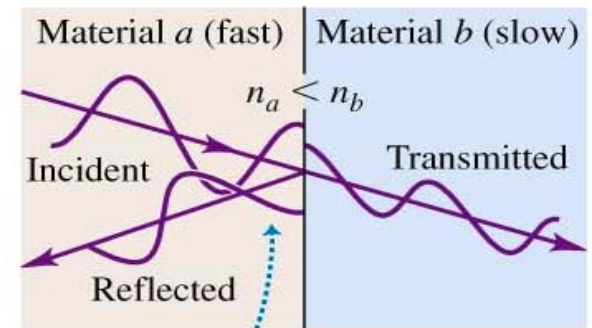
(b) If the incident and transmitted waves have the same speed ...



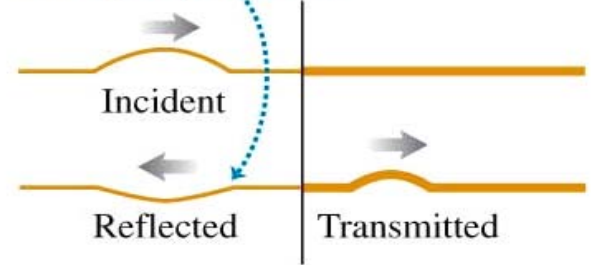
... there is no reflection.



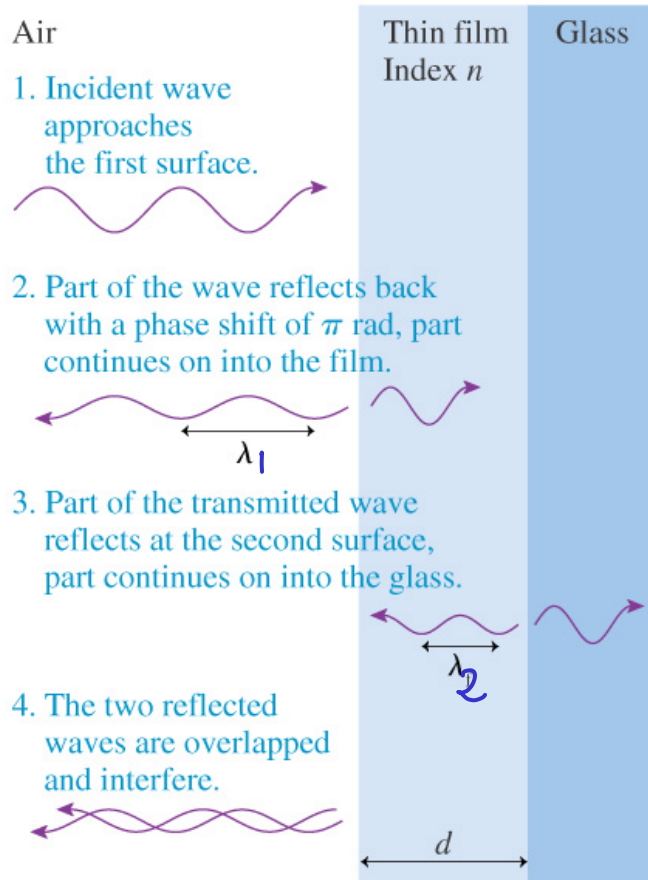
(c) If the transmitted wave moves slower than the incident wave ...



... the reflected wave undergoes a half-cycle phase shift.



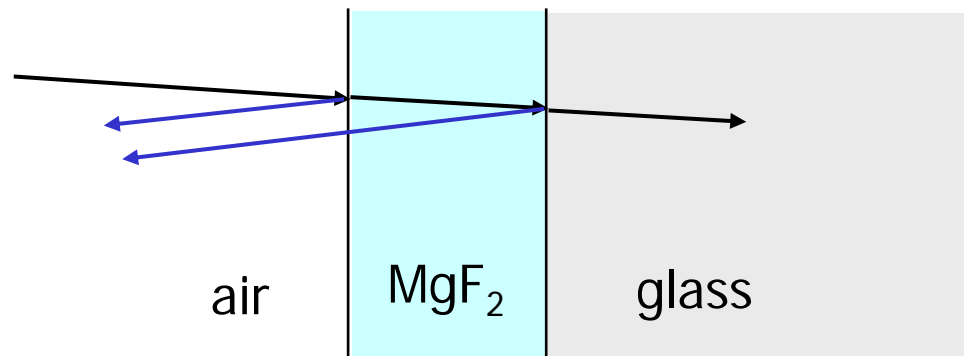
Example: Thin film



Quick Quiz

To reduce reflections from glass lenses ($n \approx 1.5$), the glass surfaces are coated with a thin layer of magnesium fluoride ($n \approx 1.39$).

Which interface causes a reflection with a phase shift?

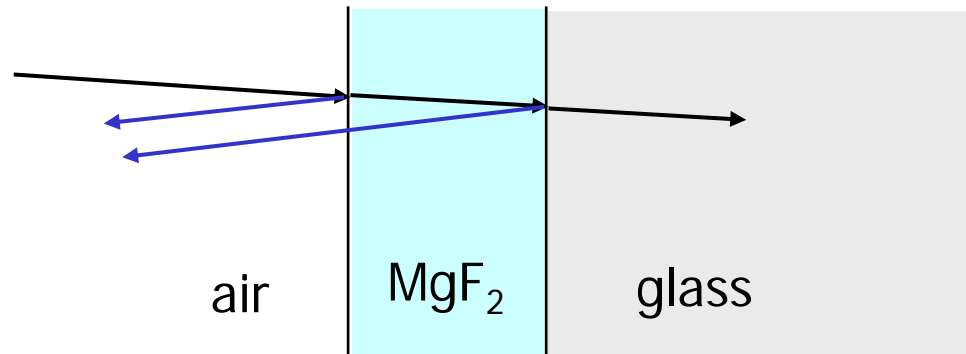


- a) The air/ MgF_2 interface
- b) The MgF_2 /glass interface
- c) Both interfaces
- d) Neither interface

Example: Antireflection coatings

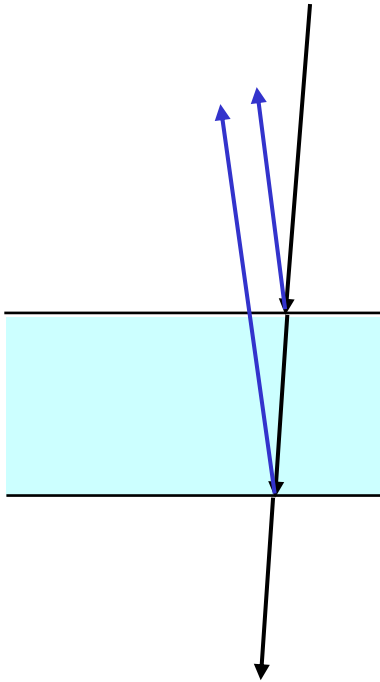
To reduce reflections from glass lenses ($n \approx 1.5$), the glass surfaces are coated with a thin layer of magnesium fluoride ($n \approx 1.39$).

What is the correct thickness of the coating for green light (510 nm vacuum wavelength)?



Quick Quiz

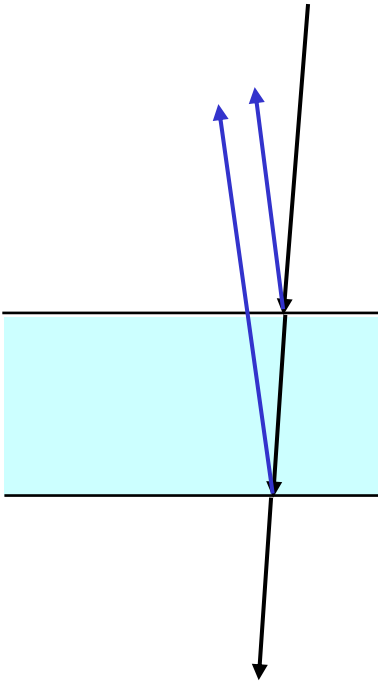
Light is incident on a soap bubble. The light travels from air ($n \approx 1.00$) into the soap film ($n \approx 1.33$), and then back out into air again. Which interface causes a reflection with a phase shift?



- a) The air-to-soap interface
- b) The soap-to-air interface
- c) Both interfaces
- d) Neither interface

Example: Thin film

What is the minimum thickness of a soap film ($n \approx 1.33$) needed to produce constructive interference for light with a 500nm wavelength? (air : $n \approx 1.00$).

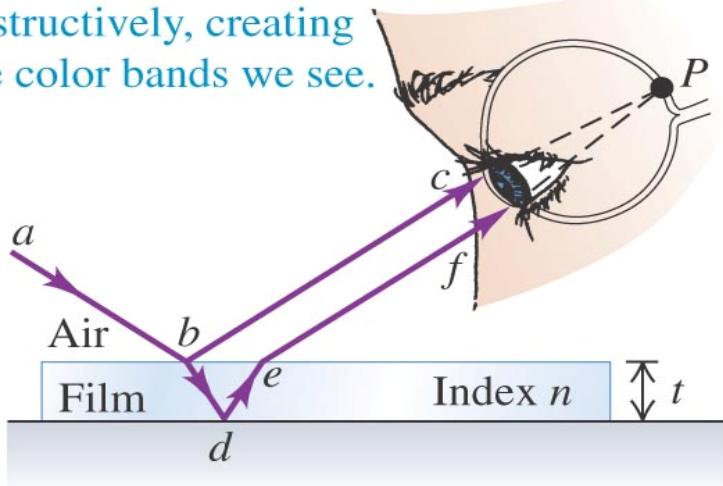


Interference in thin films

(a) Interference between rays reflected from the two surfaces of a thin film

Light reflected from the upper and lower surfaces of the film comes together in the eye at P and undergoes interference.

Some colors interfere constructively and others destructively, creating the color bands we see.



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(b) The rainbow fringes of an oil slick on water



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