Thin Film Interference
Lesson Notes

Learning Outcomes

- How can a Wave Model of light be used to explain the iridescent colors observed in a soap film or oil film?

Interference

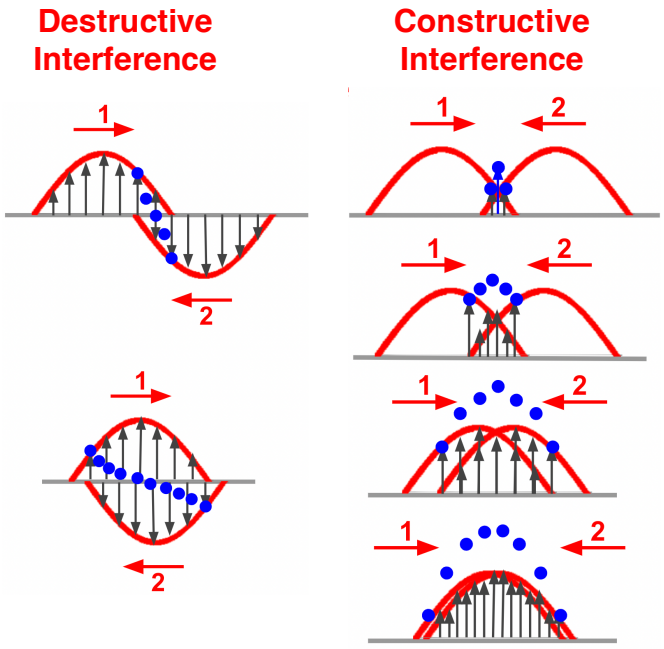
Interference occurs when two or more waves meet up while traveling through the same medium.

Constructive Interference

Occurs wherever an upward-displaced wave meets up with another upward-displaced wave (or two downward-displaced waves meet).

Destructive Interference

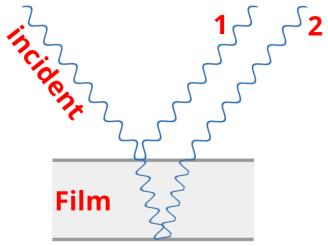
Occurs wherever an upward-displaced wave meets up with a downward-displaced wave.



Iridescence

The short-lived streaks of color seen in an oil film or soap film is an interference effect that can only be explained by a **Wave Model** of light.

The iridescent colors are the result of **thin film interference**.

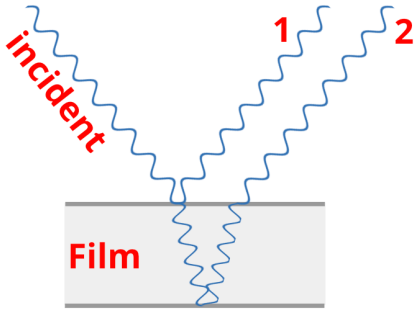


Under certain conditions, wave 1 and wave 2 will constructively interfere. This intensifies the brightness of the reflected light and results in a color.

Conditions for Constructive Interference

Wave 1 and 2 constructively interfere if …

1. … they are relatively close to each other (so that there crests and troughs meet)
2. … they are in phase with each other (crests are aligned with crests and troughs with troughs)



Condition 1 is met if the light is incident ⊥ to surface.
Condition 2 is met only for a certain wavelength of light. The actual wavelength that satisfies the condition depends on the thickness of the film.

Wave 2 will emerge from the film in phase with wave 1 as long as the extra distance traveled through the film equals a whole number of wavelengths.

If Path Difference = 1•**λ** or 2•**λ** or 3•**λ** or … *, then wave 1 will have its crests lines up with the crests of wave 2 (i.e., the two waves will be in phase).

If $2 \cdot t = n \cdot \lambda_{film}$*
(where n = 1, 2, 3, …)
Then constructive interference occurs and that specific wavelength is intensified.

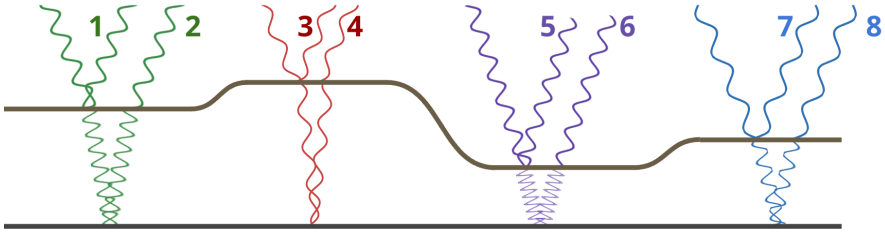
* Please see **Disclaimer** before delving too deeply into the math; it's more complicated than presented.

Disclaimer

Light reflection can be accompanied by an inversion or phase shift. To simplify the discussion, we will assume no inversion.

Iridescence in Oil and Soap Film

Consider a magnified view of an oil film of varying thickness.



The thickness at different locations allows different wavelengths or colors to be intensified at those locations.

Longer wavelength colors (like red and orange) appear at thicker locations; shorter wavelength colors (like blue and violet appear at thinner locations).

Wakelike Nature of Light

- Interference phenomenon are wave phenomenon.
- The streaks of color in a film of soap or oil are evidence that light is behaving in a wavelike manner.
- While the mathematics of thin films (simplified in this presentation) can be complicated, the concept to be driven home is that light displays wavelike characteristics and only a wave model can explain such thin film behaviors.

Photo Credit:
https://commons.wikimedia.org/wiki/File:Soap_Bubble_-_foliage_background_-_iridescent_colours_-_Traquair_040801.jpg