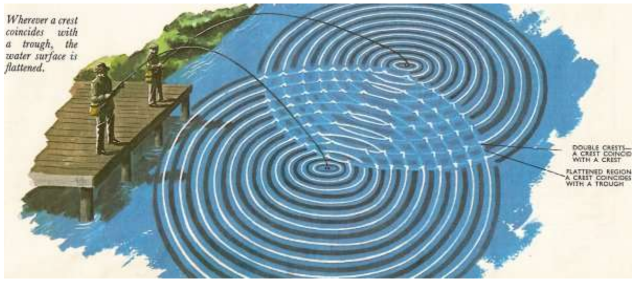
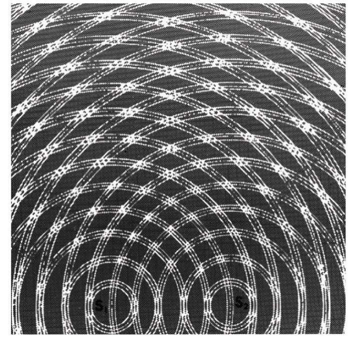
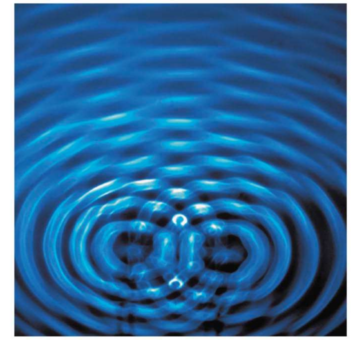


Ch 35: Interference

How waves interact with each other and with objects

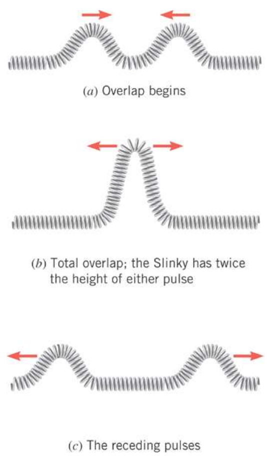




The Principle of Linear Superposition

Constructive Interference

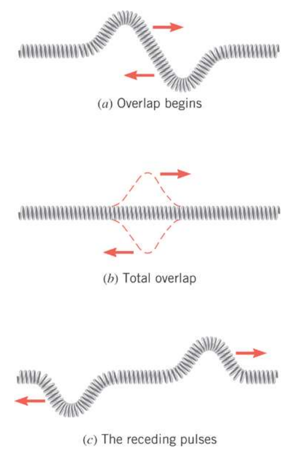
When the pulses merge, the Slinky assumes a shape that is the sum of the shapes of the individual pulses.



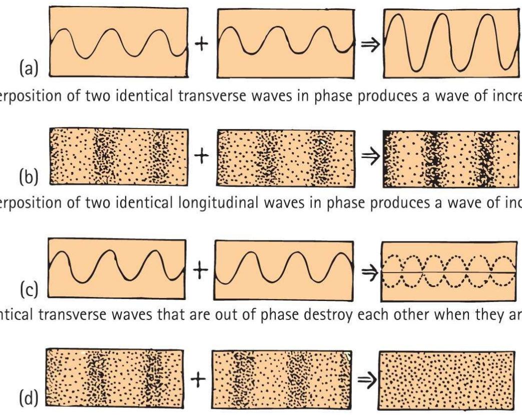
The Principle of Linear Superposition

Destructive Interference

When the pulses merge, the Slinky assumes a shape that is the sum of the shapes of the individual pulses.



Superposition



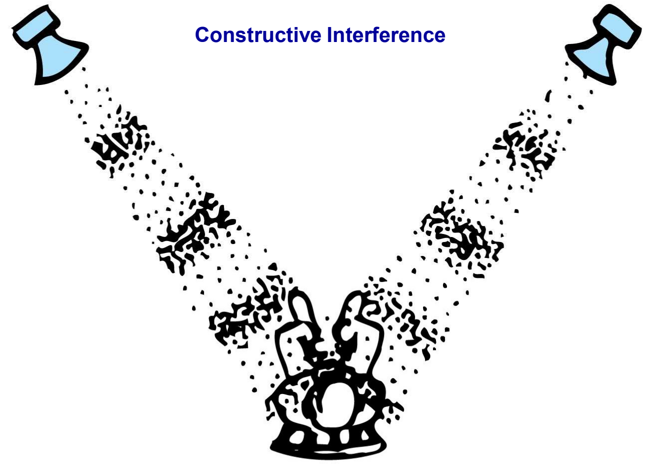
(a) The superposition of two identical transverse waves in phase produces a wave of increased amplitude.

(b) The superposition of two identical longitudinal waves in phase produces a wave of increased intensity.

(c) Two identical transverse waves that are out of phase destroy each other when they are superimposed.

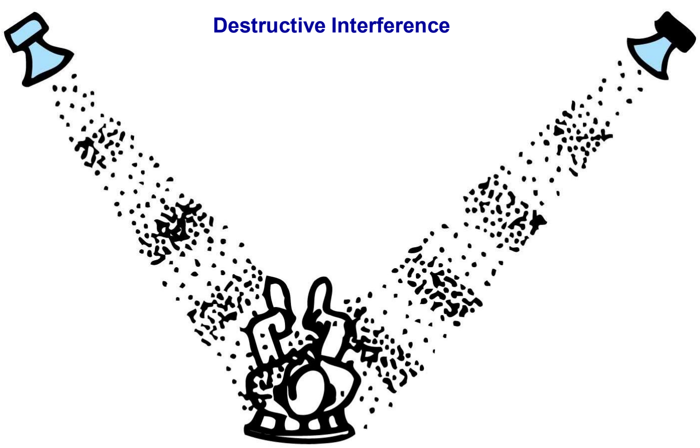
(d) Two identical longitudina waves that are out of phase destroy each other when they are superimposed.

Constructive Interference



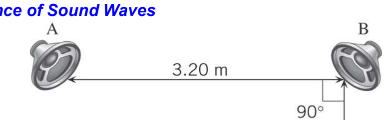
a

Destructive Interference



b

Constructive and Destructive Interference of Sound Waves

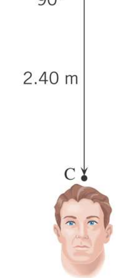


Example: **What Does a Listener Hear?**

Two in-phase loudspeakers, A and B, are separated by 3.20 m. A listener is stationed at C, which is 2.40 m in front of speaker B.

Both speakers are playing identical 214-Hz tones, and the speed of sound is 343 m/s.

Does the listener hear a loud sound, or no sound?



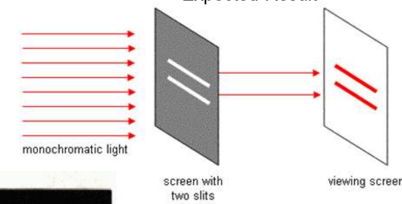
1801: Thomas Young's Double Slits Experiment

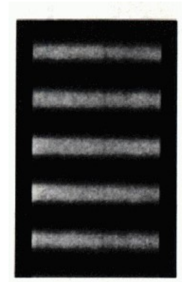
Light passing through a single slit exposed radiographic film in one wide area.

What would happen when light passed through two slits?

1801: Thomas Young's Double Slits Experiment

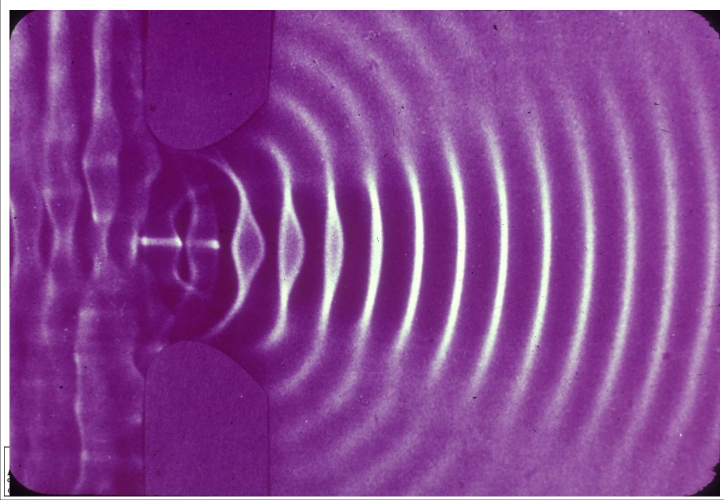
Expected Result



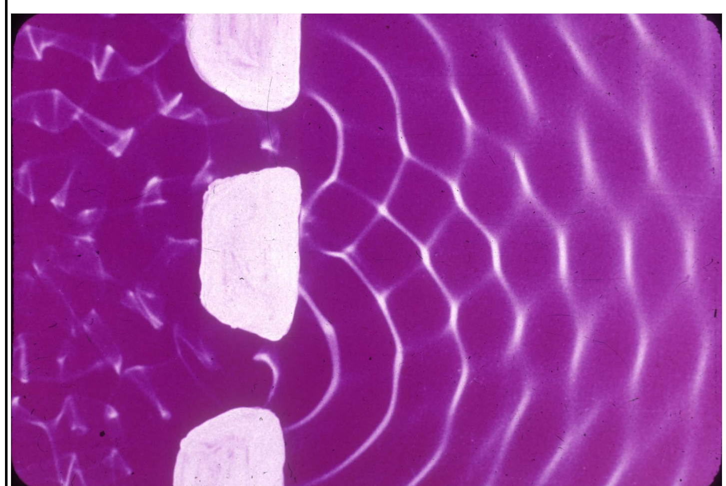


Observed Result!!

Water Waves through Single Opening



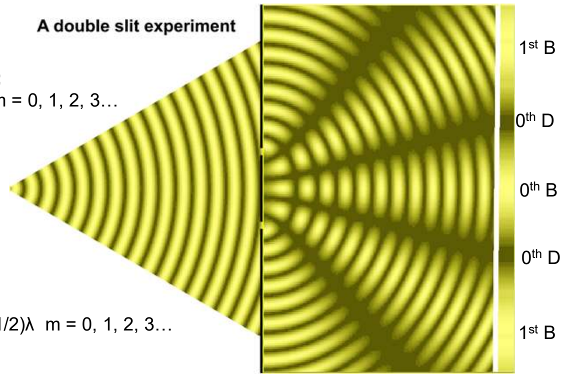
Water Waves through Double Opening



Light Must be a Wave!!!!

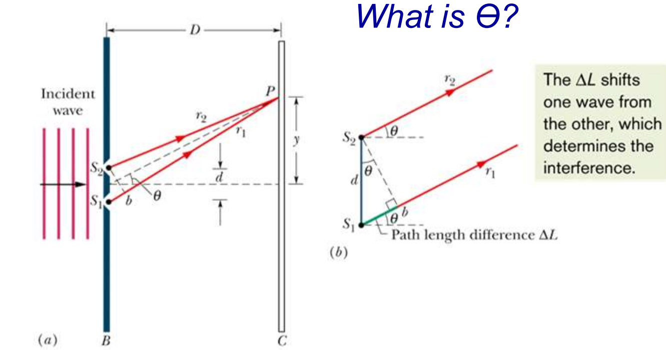
A double slit experiment

Brigh fringes:
$d \sin\Theta = m\lambda$ $m = 0, 1, 2, 3\ldots$



Dark fringes:
$d \sin \Theta = (m+1/2)\lambda$ $m = 0, 1, 2, 3\ldots$

What is Θ?



Bright Fringes

$\frac{\Delta L}{\lambda} = 0, 1, 2, \ldots$ (fully constructive interference)

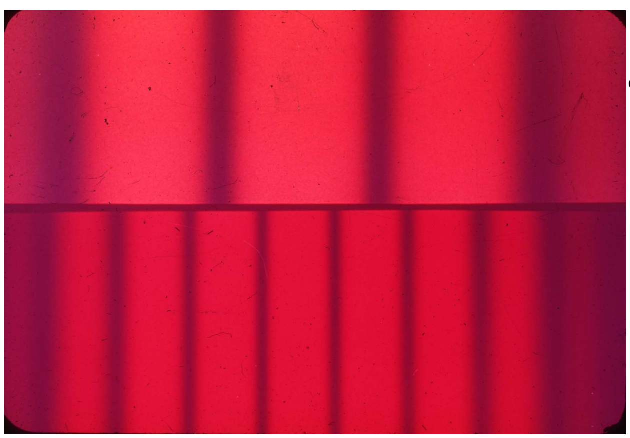
$d \sin\theta = m\lambda, \quad \text{for } m = 0, 1, 2, \ldots$

Dark Fringes

$\frac{\Delta L}{\lambda} = 0.5, 1.5, 2.5, \ldots$ (fully destructive interference)

$d \sin\theta = (m + \frac{1}{2})\lambda, \quad \text{for } m = 0, 1, 2, \ldots$

Different d

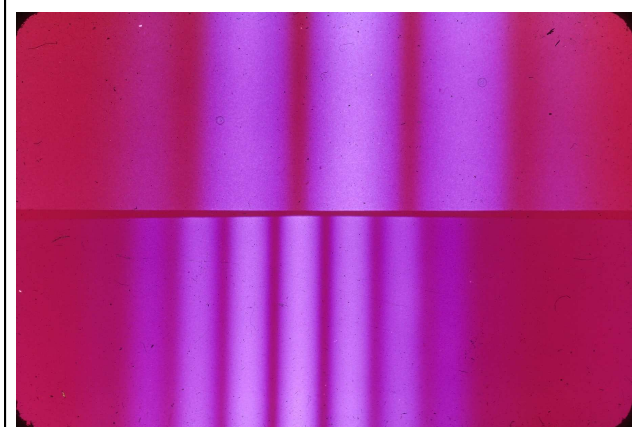


d = 0.2 mm

d = 0.4 mm

Length from slit to film = 1.5 meters

Different λ

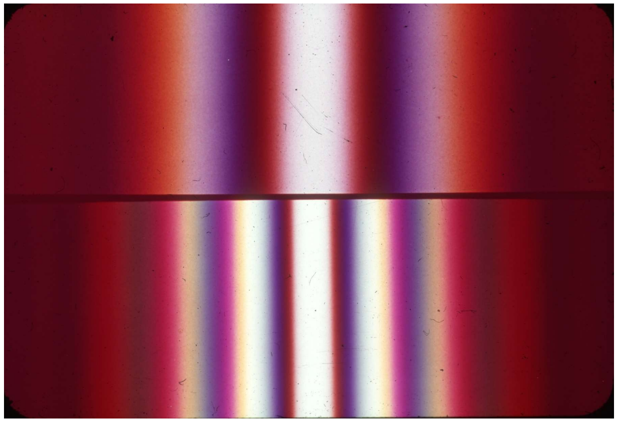


d = 0.2 mm

d = 0.4 mm

Length from slit to film = 1.5 meters

Different color = Different f = Different λ



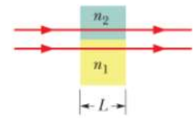
d = 0.2 mm

d = 0.4 mm

Length from slit to film = 1.5 meters

Index of refraction and phase shift

The difference in indexes causes a phase shift between the rays.



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

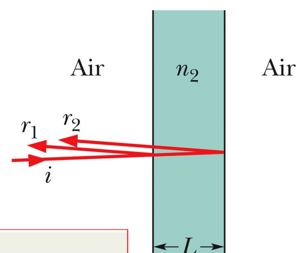
where λ is the wavelength of vacuum

$$\frac{\Delta L}{\lambda} = 0, 1, 2, \ldots \quad \text{(fully constructive interference)}$$

$$\frac{\Delta L}{\lambda} = 0.5, 1.5, 2.5, \ldots \quad \text{(fully destructive interference)}$$

Thin Films Interference

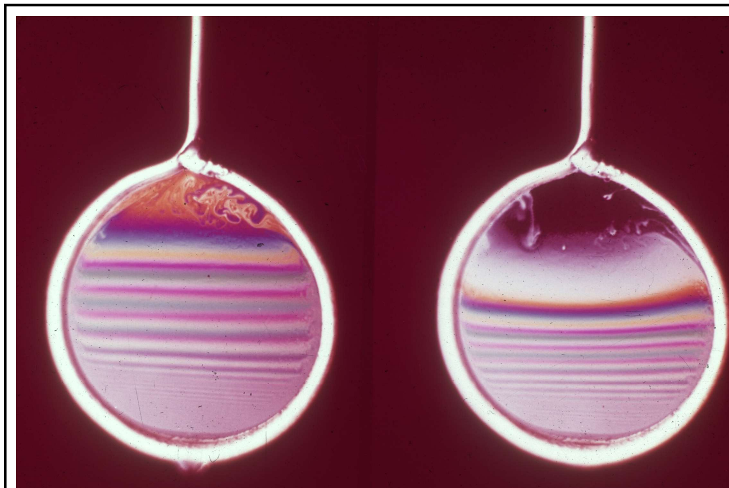
When light is incident on a thin transparent film, the light waves reflected from the front and back surfaces interfere. For near-normal incidence, the wavelength conditions for maximum and mini- mum intensity of the light reflected from a film with air on both sides are:

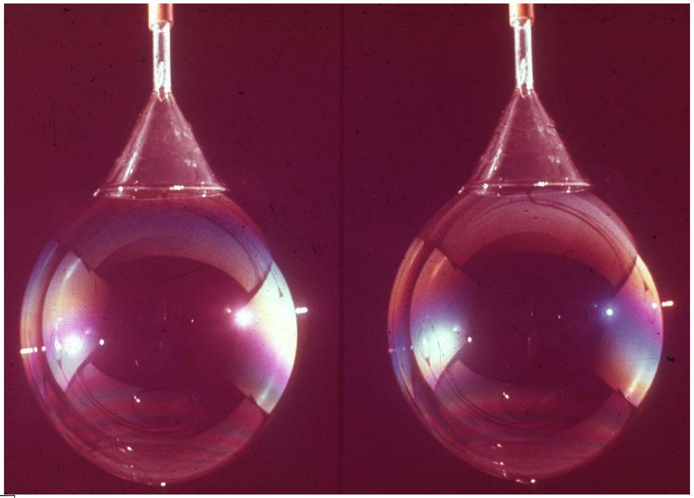


$$2L = \left(m + \tfrac{1}{2}\right)\frac{\lambda}{n_2}, \quad \text{for } m = 0, 1, 2, \ldots \quad \text{(maxima—bright film in air)}.$$

$$2L = m\frac{\lambda}{n_2}, \quad \text{for } m = 0, 1, 2, \ldots \quad \text{(minima—dark film in air)}.$$

Note: If a film is sandwiched between media other than air, these equations for bright and dark films may be interchanged, depending on the relative indexes of refraction.





Michelson's Interferometer

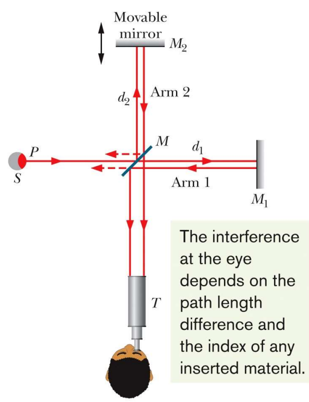
A light wave is split into two beams that then recombine after traveling along different paths.

The interference pattern they produce in the telescope depends on the difference in the lengths of those paths and the indexes of refraction along the paths.

If a transparent material of index n and thickness L is in one path, the phase difference (in terms of wavelength) in the recombining beams is equal to:

$$\text{phase difference} = \frac{2L}{\lambda}(n-1),$$

where λ is the wavelength of the light.



Brian Green & Stephen Colbert Explain Gravitational Waves

https://www.youtube.com/watch?v=ajZojAwfEbs