Interference
Chapter 35

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Chapter 35
Interference and coherent sources

- Reminder of the form of E&M Waves

\[ E(x,t) = E_0 \sin(kx - \omega t + \phi) , \text{ with} \]
\[ k = \frac{2\pi}{\lambda} \quad \text{and} \quad \omega = 2\pi f \]
Interference and coherent sources

(a)

(b) Constructive interference at point $b$: path difference = a whole number of wavelengths

(c) Destructive interference at point $c$: path difference = a half-integral number of wavelengths
Constructive and Destructive Interference

- **Constructive**
  \[ r_2 - r_1 = m \lambda \quad (m = +/- \text{ integer values}) \]

- **Destructive**
  \[ r_2 - r_1 = (m + \frac{1}{2}) \lambda \quad (m = +/- \text{ integer values}) \]
How does light bounce off these thin films?????

Light will bounce off both the top and bottom surfaces of a thin film...

There will be two different phase changes at these interfaces since the indices of refraction change

Phase change of $\pi$

$n_{\text{air}} < n_{\text{oil}}$

No phase change

$n_{\text{oil}} > n_{\text{water}}$

There will be an additional phase change due to the difference in optical paths of the two rays...
Phase changes upon reflection

From Maxwell’s Equations:

\[ E_r = \frac{n_a - n_b}{n_a + n_b} E_i \]
Phase changes upon reflection

Phase change of reflected ray by $\pi$ when $n_2 > n_1$

No phase change for the reflected ray when $n_2 < n_1$
Wedge of Air between parallel plates of glass...

Phase change at reflection from top plate is 0 but phase change at the reflection from the bottom plate $(\pi)$ plus the difference in optical paths in air wedge $(2t)$..
Newton’s Rings...

Interference is used to measure the radius of curvature of a spherical mirror....
Examples of air wedges....

Flat pieces of glass
pattern of regular fringes

Not so flat pieces of glass
fringes more ragged.
Soap Film Interference Pattern

Soap film approximately uniform in thickness

Phase shift of $\pi$

No phase shift

$n = 1.35$

$n = 1.00$

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Anti-reflection Coatings on glasses

Phase shift $\pi$ when $n$ of coating is smaller than $n$ of glass
Michelson Interferometer.

This device uses interference to make precise measurements of distances.
Other uses of an interferometer

Can use these devices to measure differences in “optical path lengths” too!
Measuring indices of refraction