Physics 102

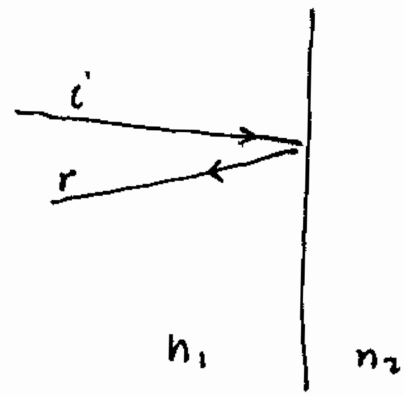
Lecture 33

Mon. Nov. 29, 2004.

- Interference in Reflected waves (28-3).

- phase changes due to reflection

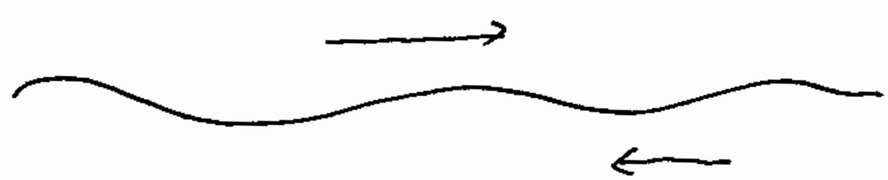
Fact:



① No phase change between ~~r~~ and i if $n_1 > n_2$.

② $\frac{\pi}{2}$ phase change if $n_1 < n_2$. e.g. air to water.
(π).

- Analogy in Mechanical wave



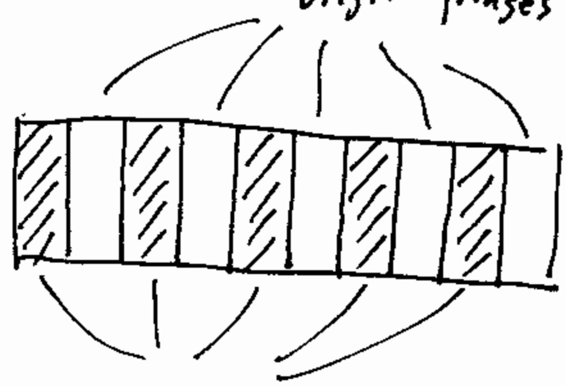
free end.
No phash shift.

Fixed end.
π phase shift.

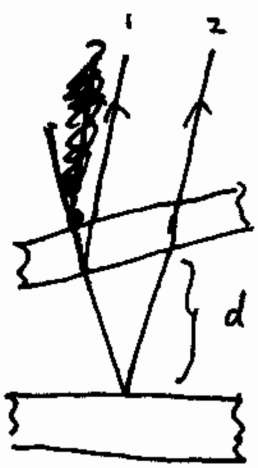
- Air Wedge.

Fact :

Top View



Explanation.



Path difference :

$$\Delta l = l_2 - l_1 \simeq 2d \quad (d\text{- thickness})$$

Effective path difference:

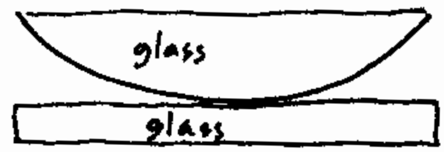
$$\Delta l_{eff} = 2d + \frac{1}{2}\lambda .$$

Bright fringes : $2d + \frac{1}{2}\lambda = m\lambda$ (constructive) $m = 1, 2, 3 \cdots$

Dark fringes : $2d + \frac{1}{2}\lambda = (m + \frac{1}{2})\lambda$ (destructive)

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

- Newton's Rings



A good way to test the shape of a lens.

Top View.

- Thin Films.

Fact: Soap bubbles look colourful.

Due to interference between reflected lights.

- When the thickness varies, different areas ~~have different~~ produce constructive interference for different wavelengths.

Demo.

why?

- What does n do?

  ↑ index of refraction — represents the interaction between light and medium.

① . speed of light is reduced.

$$v = \frac{c}{n}.$$

② . Wavelength of light is reduced.

$$\lambda_n = \frac{\lambda_0}{n}.$$

Note: frequency does not change: $f_n = f_0$.

~~[illegible]~~

$$f = \frac{v}{\lambda} = \frac{c}{\lambda_0} = f_0$$

Remember: $\boxed{\lambda_n < \lambda_0}$.

The wavelength in a medium is shorter than the wavelength in vacuum.

- e.g. Conceptual checkpoint 28-1.

A two-slit interference experiment is performed in the air. Later, the same apparatus is immersed in water and the experiment is repeated.

Q: The fringes are:

(a). more closely spaced ?

(b) more widely spaced ?

(c) spaced the same as in air ?

correct: (a).

$\because \quad d \cdot \sin\theta = m\lambda$.

fringe spacing: $\frac{y_m}{m} \approx L \cdot \frac{\lambda}{d}$. $\propto \lambda$.

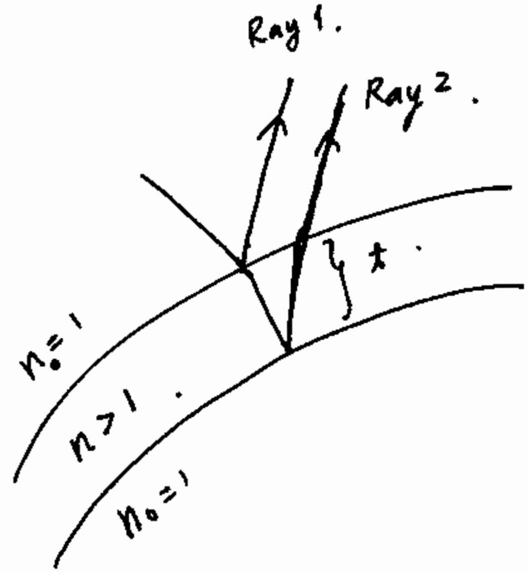
$$\left(\begin{aligned} y_m &= L \cdot \tan\theta_m \\ &\approx L \sin\theta_m \\ &= L \cdot \frac{m\lambda}{d} \end{aligned} \right)$$

~~The smaller~~

In water, λ is shorter,

Therefore, fringe spacing is smaller.

e.g. Soap bubbles.



Ray 1: $l_{eff}^{1} = \frac{1}{2}\lambda_0$

Ray 2: $l_{eff}^{2} = 2t$

Problem: wavelength inside the film is different from the wavelength ouside. i.e. $\lambda_0 \neq \lambda_n$.

(can not use $\Delta l_{eff} = m\lambda$).

We can look at the phase shift

$$E = E_0 \cdot \cos(kx - \omega t + \varphi) \qquad \left(k = \frac{2\pi}{\lambda}\right)$$

- phase shift of Ray 1: π.

Phase shift of Ray 2: $k \cdot 2t = \frac{2\pi \cdot 2t}{\lambda_n}$.

phase shift between Ray 1 and Ray 2:

$$\frac{2\pi \cdot 2t}{\lambda_n} - \pi = \frac{4\pi t}{\lambda_n} - \pi = \left(\frac{4t}{\lambda_n} - 1\right)\pi.$$

- constructive interference:

$$\left(\frac{4t}{\lambda_n} - 1\right)\pi = 2m\pi \qquad (m = 0, 1, 2, \cdots)$$

i.e. $\frac{2t}{\lambda_n} - \frac{1}{2} = m$, OR: $\boxed{\frac{2nt}{\lambda_0} - \frac{1}{2} = m, \quad m = 0, 1, 2, \cdots}$

- Destructive interference.

$$\left(\frac{4t}{\lambda_n} - 1\right)\pi = (2m-1)\pi \qquad m = 0, \pm 1, \pm 2 \cdots$$

$$\frac{2t}{\lambda_n} = m, \quad \text{OR.} \quad \frac{2nt}{\lambda_0} = m, \quad m = 0, 1, 2, \cdots$$

Final Exam will cover: Everything. Throughout the semester.

~~Ch. 22, 23~~

Ch. 19, 20, 21, 22, 23. 25. 26, 28 ALL.

plus. Ch. 24. 27. — parts covered by lectures.

Assignments : ALL.

No sample final.

Real Final Exam : ~12 Questions. (3 times as long as a midterm)