17.4: Thin Film Interference

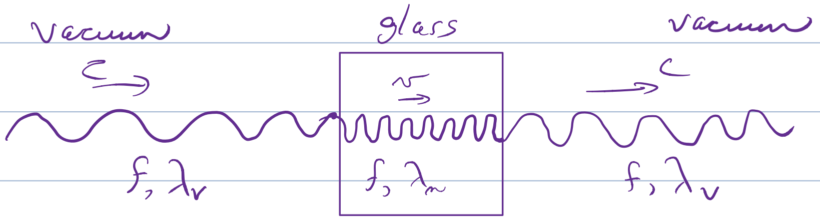
Two detours:

1. Index of refraction (see section 17.1). Light slows down when it passes through a medium.

Define index of refraction n by

$$\boxed{n = \frac{c}{v}} \quad \begin{matrix} \leftarrow \text{speed in vacuum} \\ \leftarrow \text{speed in the medium} \end{matrix}$$

medium	n
vacuum	1
air	1.00029 → usually assume 1
water	1.33
typical glass	1.6



f is the same (no piling up of crests!)

$v = \lambda f$ is still true. ∴ λ changes

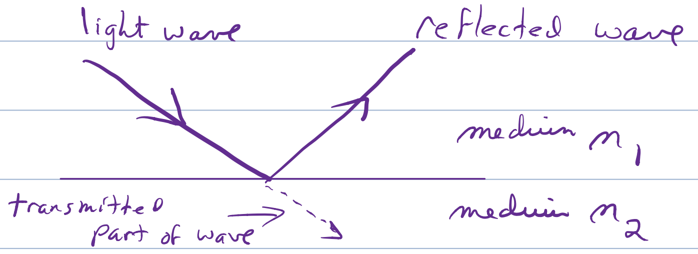
vacuum: $\lambda_v = c/f$

medium: $\lambda_n = v/f = \dfrac{(c/n)}{f} = \dfrac{1}{n}\lambda_v$

Wavelength in a medium is shorter: $\boxed{\lambda_n = \dfrac{\lambda_v}{n}}$

By convention, we will usually specify vacuum wavelength.

2. Phase change upon reflection

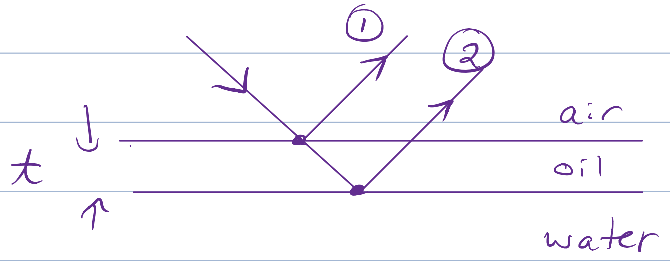


- If $n_1 < n_2$ (eg. air/glass) reflected wave is <u>inverted</u>.
- If $n_1 > n_2$ (e.g. glass/air) reflected wave is <u>not inverted</u>.

(This is similar to what we saw with waves on a rope.)

17.4 Thin Film Interference

Consider a thin film (e.g. oil) on top of water.



How do reflected waves ① and ② combine?

There are two factors to consider

- optical path length difference
- phase changes upon reflection

Simplification: assume normal incidence

$\Delta r = 2t$ (straight down and back).

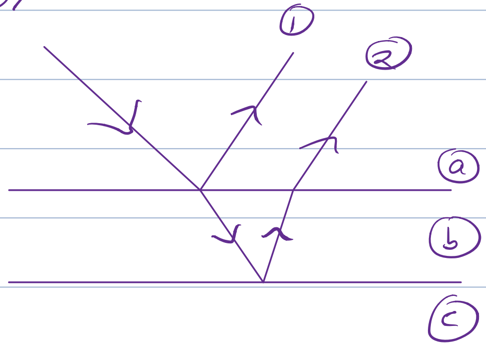
For interference, compare Δr to $m\lambda$ (m = integer). Which λ? The λ in the medium (oil in this case.)

Thus if $\Delta r = m\lambda_n$

$$2t = m\frac{\lambda_v}{n}$$

compare $\underbrace{2nt}_{\text{optical path length}}$ to $m\lambda_v$

Thin film strategy:



Is wave ① inverted?

Is wave ② inverted?

What is the optical path length difference $2n_b t$?

Examples: Anti-reflective coating (ch17-thin-film-1)

oil on water (ch17-thin-film-2)