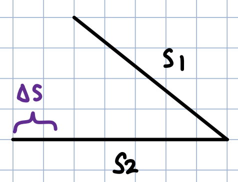
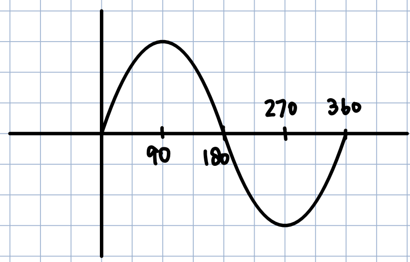
Path Difference:



Phase Shift



$\Delta S = \frac{\lambda}{2}$ Destructive interference

PS: 180°, 540°, 900°

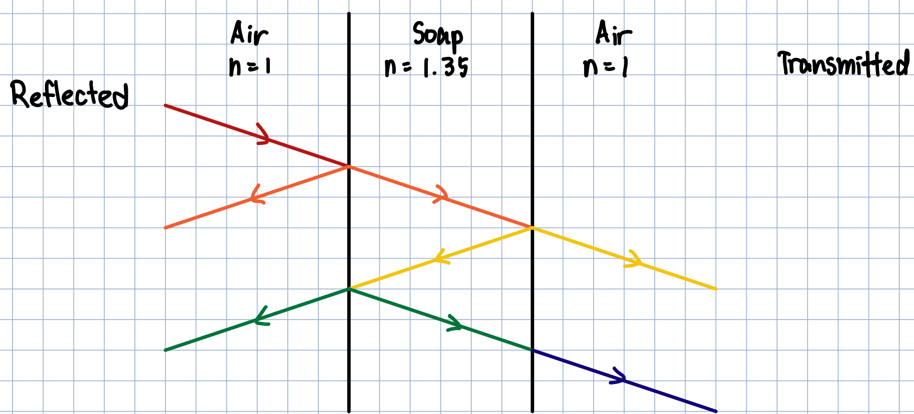
$\Delta S = \lambda$ Constructive interference

PS: 0°, 360°, 720°

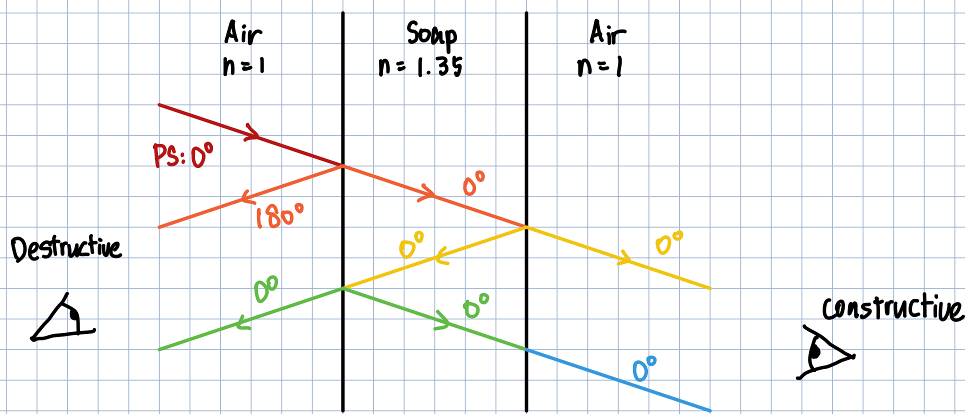
Thin Films

Now we are ready to consider rays of light traveling through a thin film. An incident ray will reflect and refract an infinite amount of times.

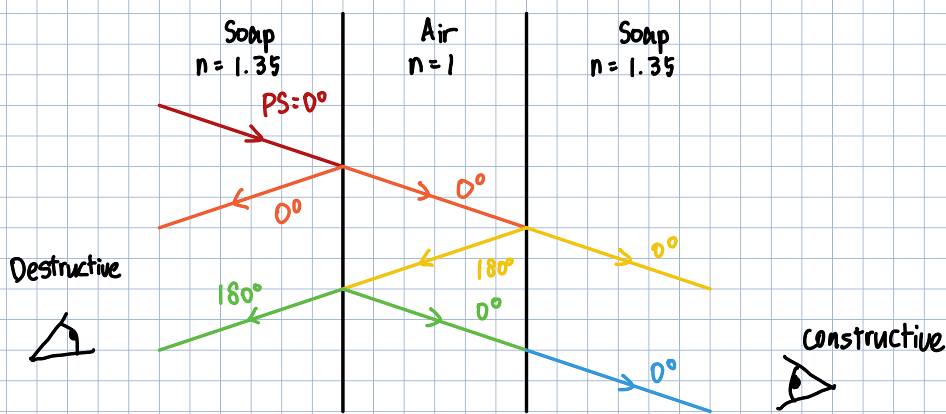
Incident rays are actually perpendicular so that reflected and refracted rays overlap/interfere but couldn't draw rays straight in an out. This is why we don't show light "bending".



Example 1:

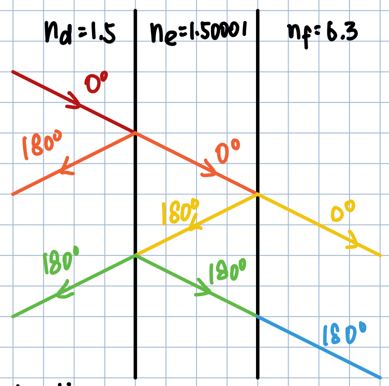


Example 2



YOU TRY :)

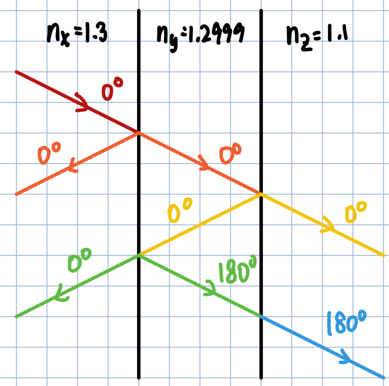
Example 3



Constructive

Destructive

Example 4



constructive

destructive

Thin film math setup

Vacuum:

$v = f\lambda$

$c = f\lambda_{vac}$ f stays the same

$c = 3\times10^8$ m/s $\lambda_{vac} = \frac{c}{f}$

Other media:

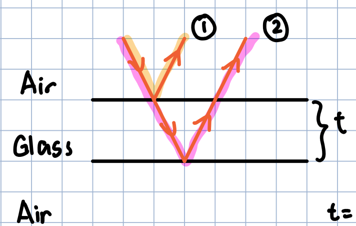
light in other media travel slower

$V_m = \frac{c}{n_m} = \lambda_m f$

$\lambda_m = \frac{c}{f n_m}$

$\lambda_m = \frac{\lambda}{n_m}$ no subscript? (vacuum / air)

Thin film:

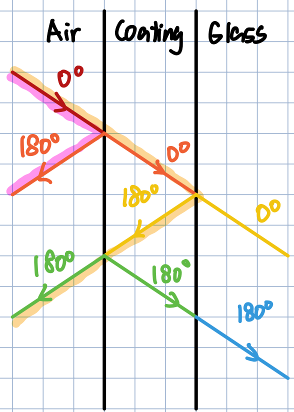


$\Delta s = s_2 - s_1 = 2t$

t = thickness

Case One:

Constructive Interference on Reflected Side Ⓡ (In phase)



$\Delta S = 2t$

$\Delta S = \lambda, 2\lambda, 3\lambda$

Integer (How many wave lengths)

$\Delta S = n\lambda_m = \frac{n\lambda}{n_m} = 2t$

$t = \frac{\lambda}{2n_m}$

$t = \frac{n\lambda}{2n_m}$

Example:

In order to get blue light (400nm) reflected, the film thickness could be any of the following. $n = 1, 2, 3$

$\lambda = 400\,nm$

$n_m = 1.4$

$t_1 = \frac{\lambda}{2n_m} = \frac{400nm}{2(1.4)}$

$= 145\,nm$

$t_2 = \frac{\cancel{2}\lambda}{\cancel{2}n_m} = \frac{400nm}{1.4}$

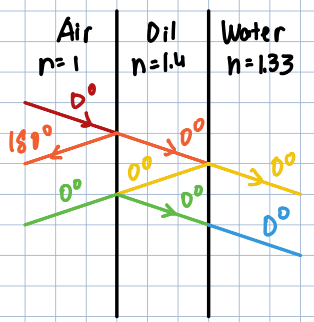
$= 286\,nm$

$t_3 = \frac{3\lambda}{2(1.4)}$

$= 429\,nm$

Case 2:

Constructive Interference on reflected side: (out of phase)



$\Delta S = \frac{\lambda m}{2} = \frac{\lambda}{2n_m} = 2t$

$\Delta S = 2t$

$\Delta S = \frac{\lambda}{2}, \frac{3\lambda}{2}, \frac{5\lambda}{2}$

$t = \frac{\lambda}{4n_m}$

$t = \frac{(n+\frac{1}{2})\lambda}{2n_m}$

Example:

In order for blue light to be reflected (400nm). find t (n=0,1,2)

$\lambda = 400nm$

$n_m = 1.4$

$t_0 = \frac{\frac{1}{2}(400)}{2(1.4)}$

$= 71.4nm$

$t_1 = \frac{(\frac{3}{2})(400)}{2(1.4)}$

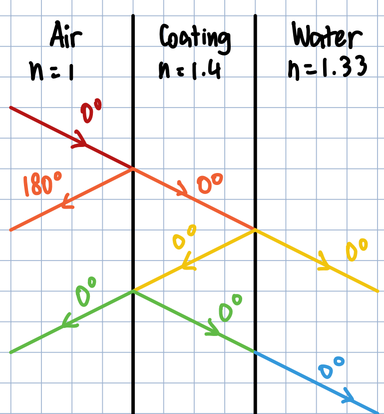
$= 214nm$

$t_2 = \frac{(\frac{5}{2})(400)}{2(1.4)}$

$= 357nm$

Case 3

Destructive Interference on reflected side (out of phase)



Rays 1 and 2 are out of phase

∴ Destructive Interference

$\Delta S = 2t$

$t = \frac{n\lambda}{2n_m}$

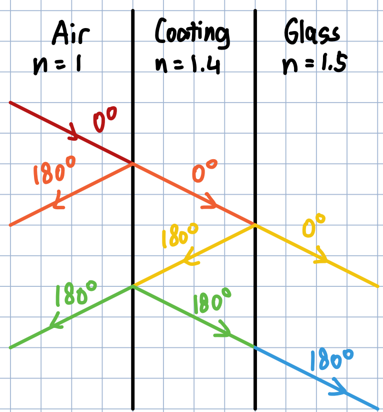
$\lambda_m = \frac{\lambda}{n_m}$

$2t = \frac{\lambda}{n_m}$

$t = \frac{\lambda}{2n_m}, \frac{\lambda}{n_m}, \frac{3\lambda}{2n_m}, \frac{2\lambda}{n_m}$, etc

Case 4

Destructive Interference on reflected side (In phase)



Rays are in phase.

to interfere destructively ray 2

has to travel such that the $\Delta S = \frac{\lambda_m}{2}$

$= 2t$

$$\frac{\lambda_m}{2} = \frac{\lambda}{2n_m}$$

$$2t = \frac{\lambda}{2n}$$

$$t = \frac{\lambda}{4n_m}$$

$$t = \frac{(n+\frac{1}{2})\lambda}{2n_m}$$