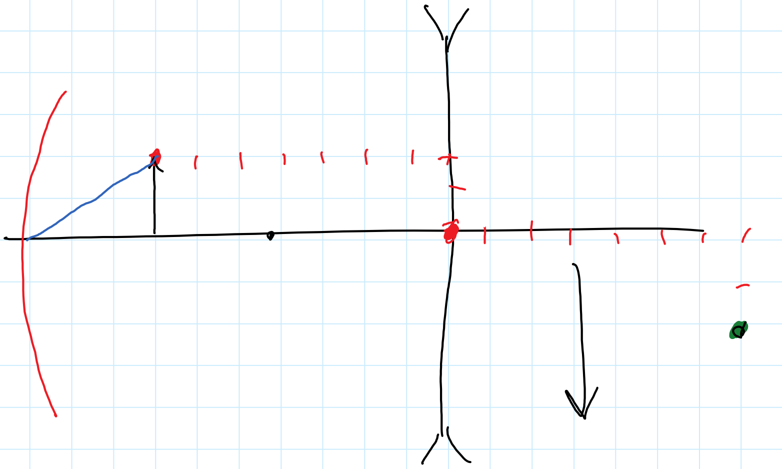
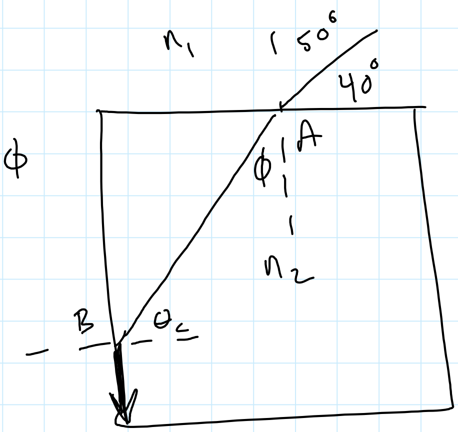
Phy 4C 3/13

Monday, March 13, 2017 10:49 AM

Interference
Polarization





A

$$\overset{=1}{n_1} \sin 50° = n_2 \sin\phi$$

$$\sin 50° = n_2 \sin\phi$$

$$\frac{\sin 50}{\sin\phi} = n_2$$

B

$$n_2 \sin\theta_c = \cancel{n_1}^{1} \cancel{\sin 90}^{1}$$

$$n_2 \sin\theta_c = 1$$

$$\theta_c = 90 - \phi$$

$$n_2 \sin(90-\phi) = 1$$

$$n_2 \cos\phi = 1$$

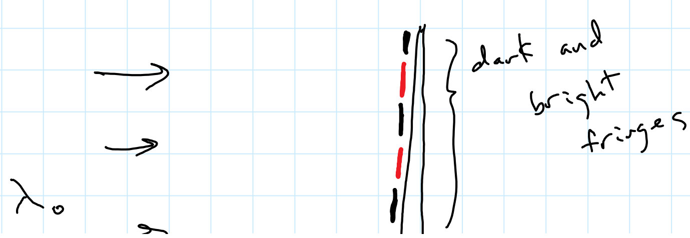
$$n_2 = \frac{1}{\cos\phi}$$

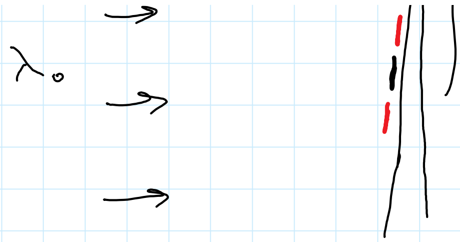
$$\tan\phi = \sin 50°$$

$$\phi = 37.45°$$

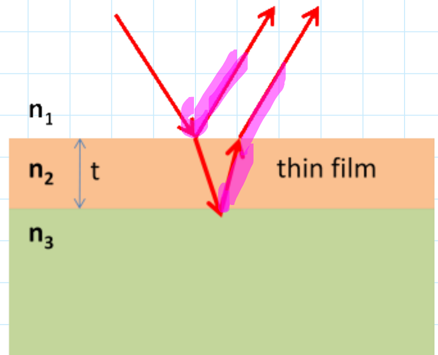
$$n_2 = 1.26$$

Thin film interference





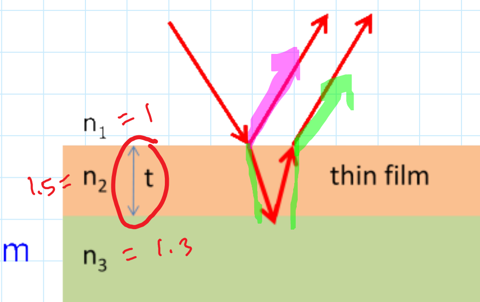
Light of wavelength λ falls almost perpendicularly on a thin film with index of refraction n_2 and thickness t. Below the thin film is an infinitely thick layer with index of refraction n_3. Which of the following equations would give **destructive** interference if $n_3>n_2>n_1$? (λ_1, λ_2, and λ_3 are the wavelengths of the light in the medium with index of refraction n_1, n_2, and n_3, respectively.)



$\Delta path = \frac{1}{2} \lambda_{film}$

1. 2t = ~0
2. 2t = 1/2 λ_1
3. 2t = λ_1
4. 2t = $1/2\lambda_2$
5. 2t = λ_2
6. Answers 1 and 2.

Light of wavelength 500nm falls almost perpendicularly on a thin film with index of refraction n_2. Below the film is an infinitely thick layer with index of refraction n_3. If $n_1 = 1$, $n_2 = 1.5$, and $n_3 = 1.3$, what is the minimum film thickness to get destructive interference?



1. 500 nm
2. 500 nm/1.5
3. 500 nm/1.3
4. 500 nm/2
5. 500 nm/3
6. ~0
7. No destructive interference can occur under this conditions.

Be careful! This time $n_2 > n_3$

phase shifted, so destructive $\Delta path = m\lambda$ for ($m=1$ for min thickness)

$2t = (1)\lambda_{film}$

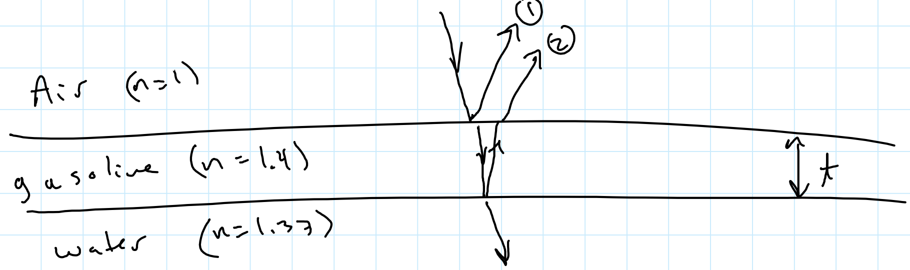
$2t = \frac{\lambda}{n_2}$

$t = 500$ nm

can occur under this conditions.

$$2t = \frac{\lambda}{n_2}$$

$$t = \frac{500\ nm}{2\ (1.5)}$$



ray ① → phase change

ray ② → No phase change, but path difference

want destructive interference of red light ($\lambda = 700\ nm$ in air) → Find minimum d

(path difference) + (Net phase changes) = multiple of λ or $\frac{\lambda}{2}$

constructive → λ; destructive → $\frac{\lambda}{2}$

$$2d + \frac{\lambda_{film}}{2} = (m + \tfrac{1}{2})\,\lambda_{film} \qquad m = 1, 2, \ldots$$

$$2d = m\,\lambda_{film}$$

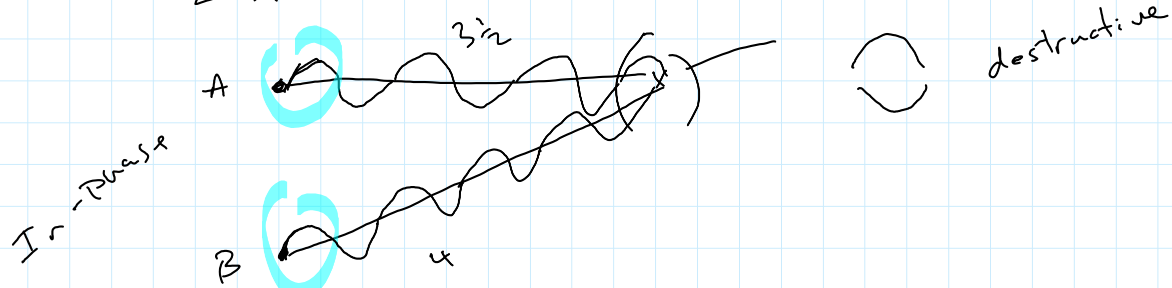
$$2d = m\,\frac{\lambda_{vacuum}}{n_{film}}$$

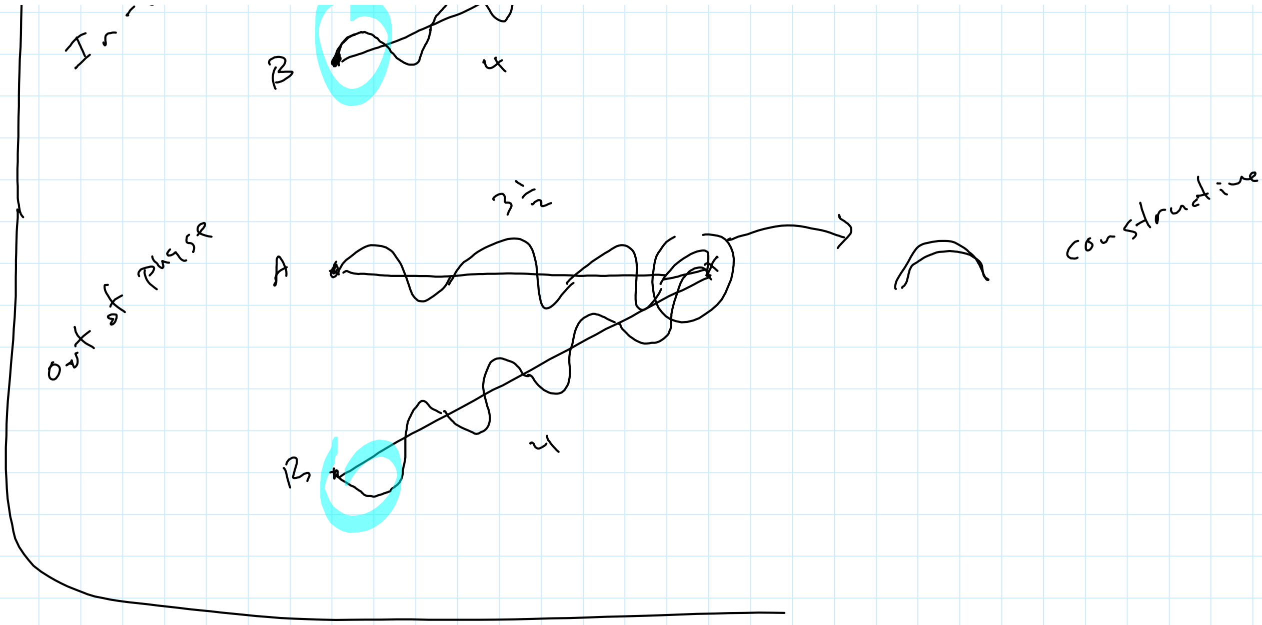
$$2d = (1)\,\frac{(700\ nm)}{1.4}$$

let m=1 for min film thickness (Non-zero)

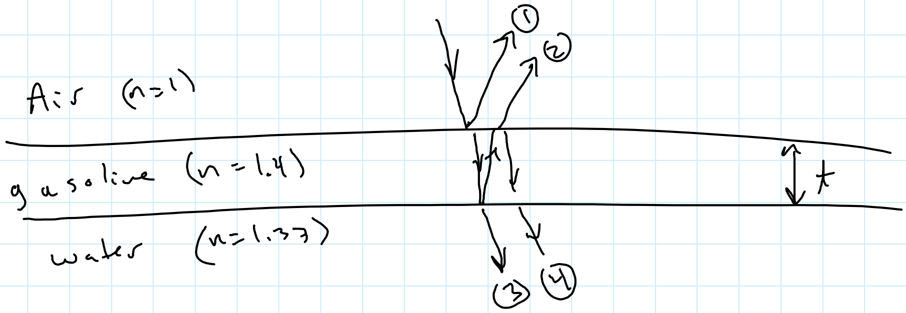
$$d = 250\ nm$$

2 speakers, sound waves





same situation as above:



want min. non-zero film thickness
for the transmitted light (into the water)
to be maximum intensity

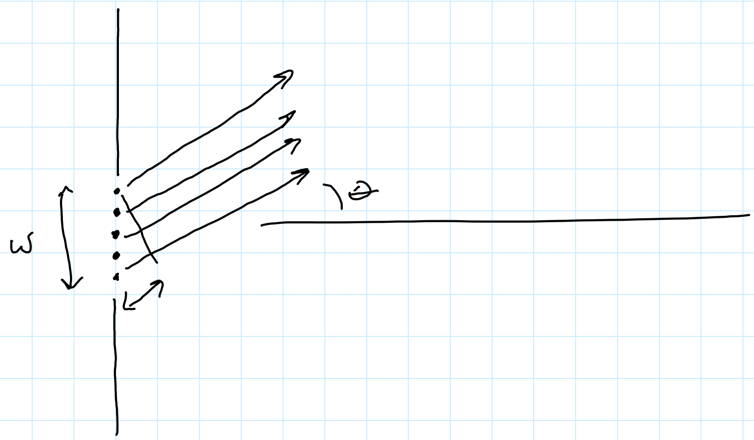
can use:
1) Rays 1 and 2 and solve for minimum reflection
or
2) Rays 3 and 4 and solve for maximum transmission

1) $$2d + \frac{\lambda_{film}}{2} = (m+\tfrac{1}{2})\lambda_{film} \quad \text{for min}$$

2) $$2d + \underbrace{0}_{\text{No phase shift between 3 and 4}} = m\,\lambda_{film} \quad \text{for max.}$$

Single Slit

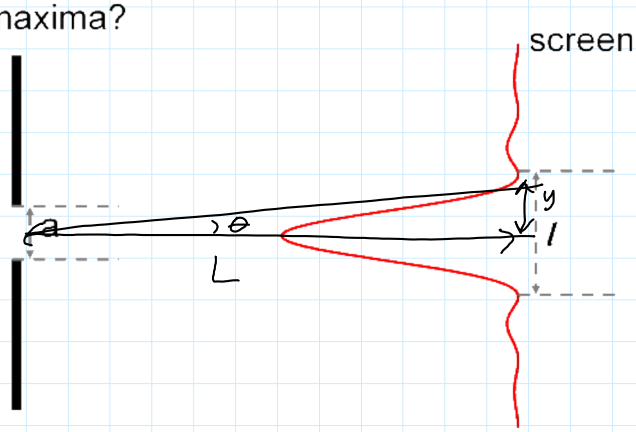
Huygen's principle says each pt acts like a source



Dark fringes: $\sin\theta = m\dfrac{\lambda}{w}$ $\quad m = 1, 2, 3, \ldots$

for sound: 1^{st} min: $\sin\theta = \dfrac{\lambda}{D}$ ← diameter

A single slit of width a is illuminated by light of wavelength λ, so that the width of the central diffraction maxima is *l*. Now you decrease the slit width to a/2. What is the width of the central diffraction maxima?



1. *l*/2
2. 2*l*
3. *l*/4
4. 4*l*
5. *l*

for small angles: $\sin\theta \simeq \tan\theta \simeq \theta = \dfrac{y}{L}$

$$\frac{y}{L} = (1)\frac{\lambda}{a}$$

This time you keep the same slit width, but use another monochromatic light of wavelength 500 nm. How does the broadness of the central bright fringe change compared to that produced by the 600 nm wavelength?

600 nm → 500 nm

1. Increases

600 nm

1. Increases
2. Decreases
3. Stays the same
4. Depends on the exact value of the slit width

The slit opening is a=10 μm and the distance between the slit and the screen is L=3 m. Calculate ℓ for light of wavelength 500 nm.

1. 0.05 m
2. 0.10 m
3. 0.15 m
4. 0.20 m
5. 0.25 m
6. 0.30 m

$$\sin\theta = m\frac{\lambda}{a}$$

$$\frac{y}{L} = (1)\frac{\lambda}{a}$$

$$\frac{\ell/2}{L} = \frac{\lambda}{a}$$

$$\ell = \frac{(3\text{ m})(500\times10^{-9}\text{ m})(2)}{(10\times10^{-6}\text{ m})} = 0.3\text{ m}$$

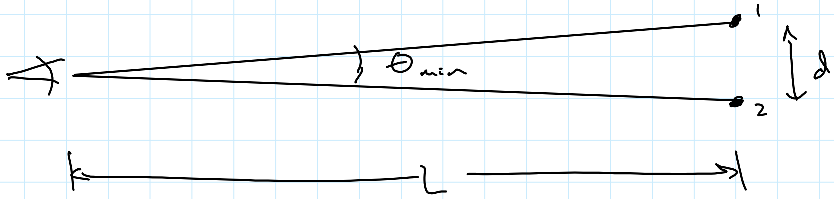
single slit: $\sin\theta_{dark} = m\frac{\lambda}{a}$ $m = \pm1, \pm2, \ldots$

a = slit width

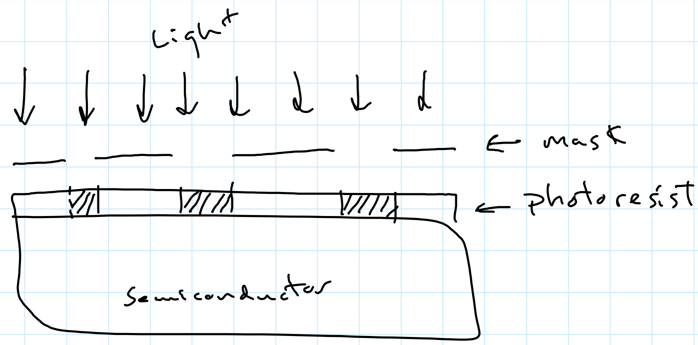
Rayleigh's Criteria: Resolution of 2 objects

$$\theta_{min} = 1.22\frac{\lambda}{D}$$

D ← diameter of the circular opening



Example: photo-lithography



as slit width gets smaller

λ must get smaller

to minimize diffraction

visible $\rightarrow$ UV $\rightarrow$ X-rays

Diffraction Grating:

$$d \sin\theta_{bright} = m\lambda \qquad m = 0, \pm 1, \pm 2, \ldots$$

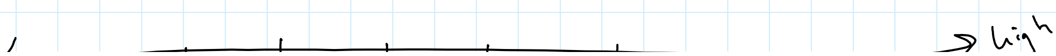
d ↑ spacing between slits

Polarization of Light

Electro-magnetic Spectrum

ϵ_0 ← constant for electric fields

μ_0 ← constant for magnetic fields



Speed of Light: $C = \frac{1}{\sqrt{\epsilon_0 \mu_0}} = 3 \times 10^8 \frac{m}{s}$