Phy 4C 3/8

Wednesday, March 8, 2017 11:56 AM

Interference

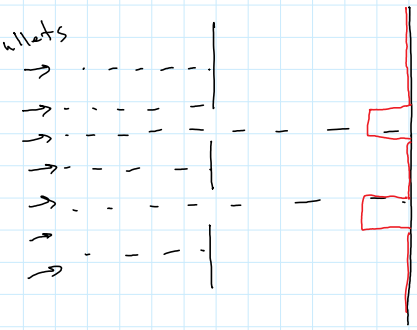
Coherent Source = maintains a constant phase relationship

(Otherwise interference would not be constant)

A Laser produces coherent light (only one wavelength)

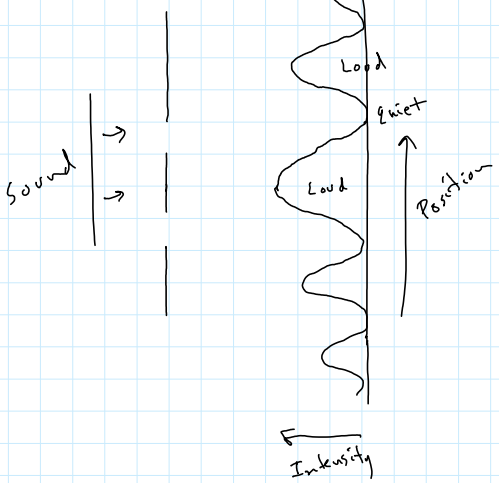
Particles

bullets

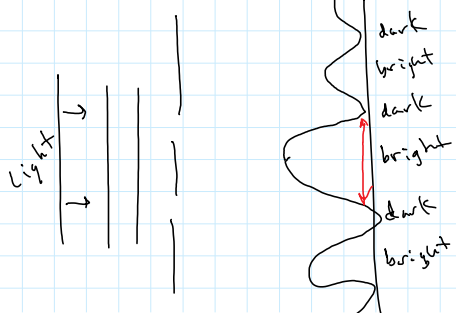


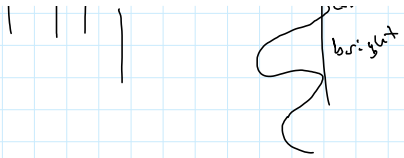
# of bullets (or intensity)

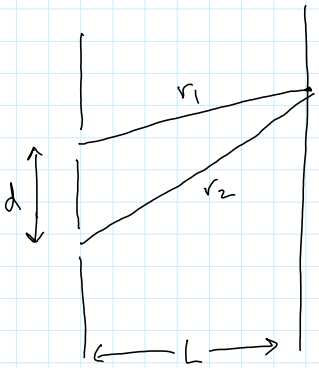
Wave



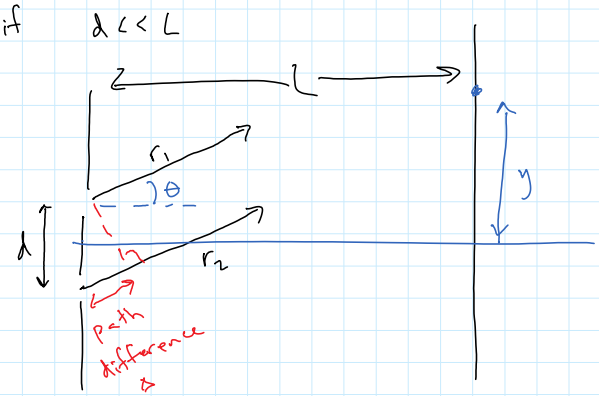
Light







if $d << L$



$\Delta = r_2 - r_1 = d \sin\theta$

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

destructive: $d \sin\theta_{dark} = \left(m + \frac{1}{2}\right)\lambda$ $\quad m = 0, \pm 1, \pm 2, \ldots$

$$\tan\theta = \frac{y}{L}$$

Example problem:

Double slit experiment w/ $\lambda = 630$ nm

$d = 5.3 \times 10^{-5}$ m

$L = 2$ m

Find y and θ for each:

a) $m = 1$ (1^{st} order bright fringe)

b) $m = 2$ (2^{nd} " " ")

c) $m = 3$ (3^{rd} " " ")

dark: $d \sin\theta = m\lambda$

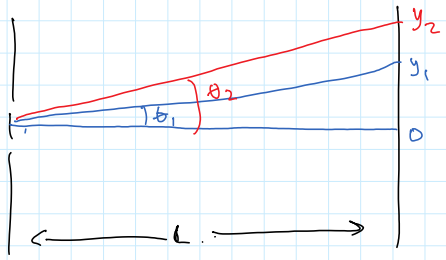
bright : $d \sin\theta_{bright} = m\lambda$

$$\theta = \sin^{-1}\left(\frac{m\lambda}{d}\right)$$

$\theta_1 = 0.68^\circ$

$\theta_2 = 1.36^\circ$

$\theta_3 = 2.04^\circ$



$\tan\theta = \frac{y}{L}$

$y_1 = 0.024$ m

$y_2 = 0.048$ m

$y_3 = 0.072$ m

Find the width of the central bright spot

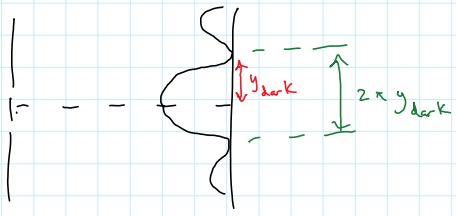
Find distance to dark fringe:

$d \sin\theta_{dark} = (m + \frac{1}{2})\lambda$ use $m=0$ for 1st dark fringe

$d \sin\theta_{dark} = \frac{\lambda}{2}$

find y_{dark}

width = $2 \times y_{dark}$



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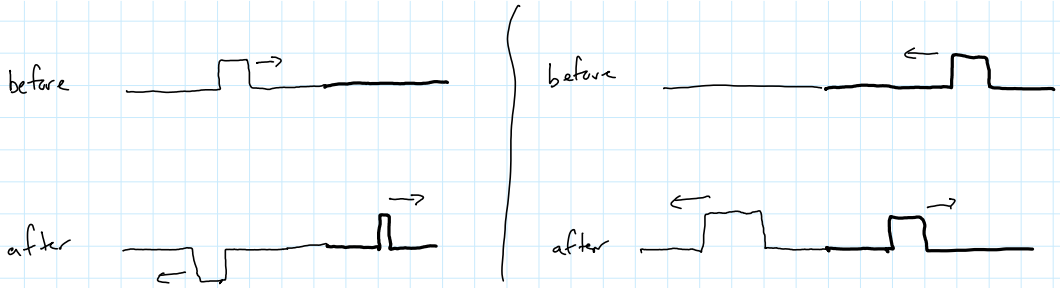

A) Soap → larger density spring (speed is slower)

B) yes → higher n means slower speed

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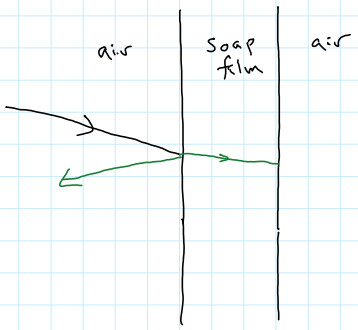
a)



b) same

c) less $\lambda_{film} = \frac{\lambda_{vacuum}}{n_{film}}$

d) fixed end

e) 180° out of phase

No phase change for transmitted (ever!)

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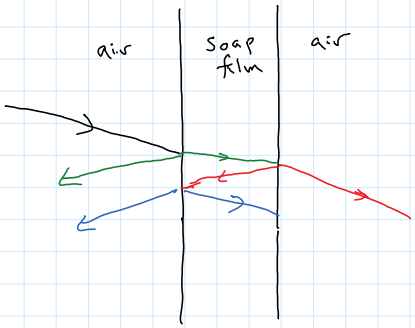
2) a



b) free end

No phase change / In phase

3) No phase change on transmission

D) $f_{air} = 7.5 \times 10^{14}$ Hz

$f_{film} = f_{air} = 7.5 \times 10^{14}$ Hz

$\lambda_{air} = \frac{c}{f_{air}} = \frac{3 \times 10^8}{7.5 \times 10^{14}} = 4 \times 10^{-7}$ m $= 400$ nm

$\lambda_{film} = \frac{\lambda_{air}}{n_{film}} = \frac{4 \times 10^{-7}}{1.33} = 3 \times 10^{-7}$ m $= 300$ nm

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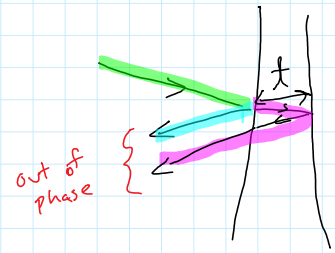


$t = 75$ nm

Δ path $= 2t = 150$ nm

2) out of phase due to reflections,

Now look at path difference

Total phase difference: $\pi + \frac{2t}{\lambda_{film}}(2\pi)$

reflections; path difference

$= \pi + \frac{2(75\text{ nm})}{300\text{ nm}}(2\pi)$

$= \pi + \pi$

$= 2\pi \Leftarrow$ in phase (bright spot)

Using λ:

$\frac{\lambda_{film}}{2} + 2t = m\lambda_{film}$

Reflections; Path difference; constructive

Reflections — Path difference

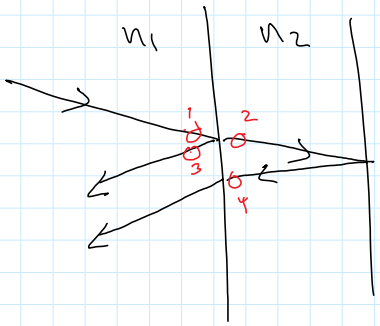
if $m = 0, 1, 2, \ldots$ Constructive or in phase

if $m = \frac{1}{2}, \frac{3}{2}, \frac{5}{2}, \ldots$ destructive or out of phase

$$\frac{300\text{ nm}}{2} + 2(75\text{ nm}) = m(300)$$

$m = 1$ in phase or constructive or bright fringe

3) bright or maximum



① → ③ reflection $n_2 > n_1$

③ is π out of phase with ①

① → ② In phase

② → ④ phase change due to distance only → No phase changes due to reflections ($n_2 > n_1$)

$$\frac{2t}{\lambda_{film}}(2\pi)$$

B) using λ:

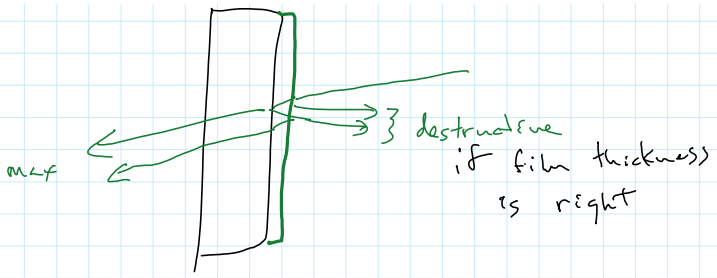
$$\frac{\lambda_{film}}{2} + 2t = m\lambda_{film}$$

$$150 + 300 = m\,300$$

$$m = \frac{3}{2}$$

out of phase or destructive or dark fringe

Want anti-reflective coating on glasses (thin film)


destructive
if film thickness
is right