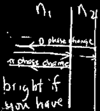
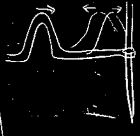
Soap film



bright if you have constructive interference

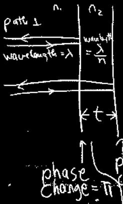
Tricky point: phase of wave will change by π if $n_2 > n_1$, no change if $n_2 < n_1$

Mechanical analogy to illustrate phase change:



§37.6 Interference in thin films

consider $n_2 > n_1$, relevant to soap film



2 paths differ in length by 2t

So constructive interference

when

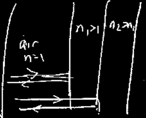
$$2t = \left(m + \tfrac{1}{2}\right)\left(\frac{\lambda}{n}\right)$$

(m ↑ integer. n ↑ index of refraction)

destructive interference when

$$2nt = m\lambda$$

(n ↑ index, m ↑ integer)



for this situation

$n_2 > n_1 > 1$

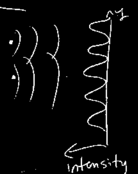
constructive interference when

$$2tn = m\lambda$$

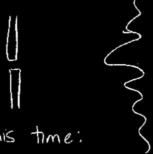
destructive interference when

$$2tn = \left(m + \tfrac{1}{2}\right)\lambda$$

§38 Diffraction effects and polarization



last time

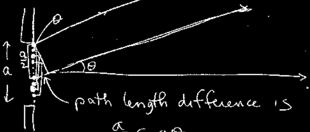


this time:

Single slit

diffraction pattern caused by interference between light from different parts of slit

Find intensity minima:



path length difference is

$\frac{a}{2}\sin\theta$

destructive interference when $\frac{a}{2}\sin\theta = \frac{\lambda}{2}$

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

also get destructive interference when

$$\frac{a}{4}\sin\theta = \frac{\lambda}{2}$$

or $\sin\theta = \frac{2\lambda}{a}$

can divide into 6 pieces

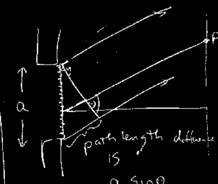
$$\frac{a}{6}\sin\theta = \frac{\lambda}{2}$$

$$\sin\theta = \frac{3\lambda}{a}$$

etc

destructive interference when $\sin\theta_{dark} = \frac{m\lambda}{a}$ $m = \pm 1, \pm 2, \ldots$

Calculate intensity vs position



$$\beta = \frac{2\pi}{\lambda}(a\sin\theta)$$

Fraunhofer diffraction pattern.

calculate intensity at P.

divide slit into zones of length Δy

let β be phase difference between top + bottom of slit phase difference $\Delta\beta$ between adjacent zones is

$$\Delta\beta = \frac{2\pi}{\lambda}\,\Delta y \sin\theta$$

N zones so

$$\beta = N\Delta\beta = \frac{2\pi}{\lambda} a \sin\theta$$

add phasors

$\theta = 0 \Rightarrow \Delta\beta = 0$

β small (θ small)

$\beta = 2\pi$

$|E_R| = 0$

1st minimum

$\beta = 3\pi$

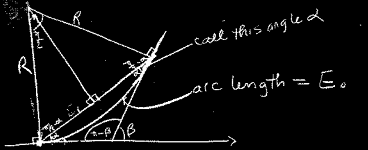
(2nd maximum)

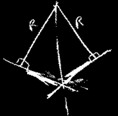
$\beta = 4\pi$

2nd minimum.

Now calculate intensity versus position

take $\Delta y \to 0$, $N\Delta y = a$





$$2\alpha + (\pi - \beta) = \pi$$
$$\Rightarrow \alpha = \beta/2$$
$$\eta + 2\left(\tfrac{\pi}{2} - \alpha\right) = \pi$$
$$\eta = 2\alpha = \beta$$

now fix R:
recall arc length of piece encompassing angle θ with radius R is $R\theta$

$$\text{So } R\eta = E_0$$
$$\eta = \beta \quad \Rightarrow R = E_0/\beta$$
$$\frac{E_R}{2} = R \sin\frac{\beta}{2} = \left(\frac{E_0}{\beta}\right)\sin\frac{\beta}{2}$$
$$E_R = E_0\left[\sin(\beta/2) \,/(\beta/2)\right]$$