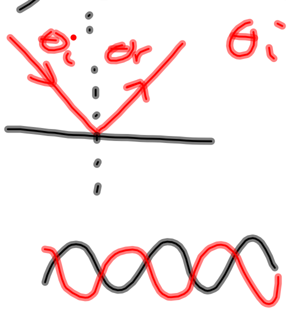
Unit 4: Light

When light hits a material, 1 of 3 things can happen...

1) It can be reflected...



$\theta_i = \theta_r$

When the light reflects of a material with higher index of refraction, n... the wave "flips" → called a phase change, or phase shift

(The opposite is not true... no P.C. when going from high n to low n.)

2) Absorbed...

The energy of the light goes into thermal energy. It can be re-emitted as light, as well.

3) Transmitted

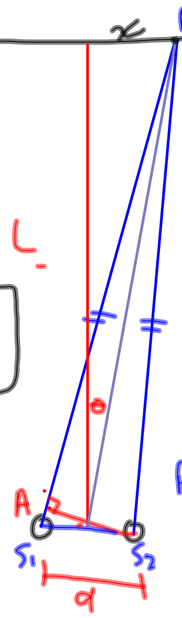
Often refraction occurs. There is no P.C.

Diffraction

→ the bending of a wave as it goes through an opening

The amount of diffraction is directly proportional to λ.
Also inversely proportional to the width of the slit. $w \leq \lambda$

Double Slit Interference



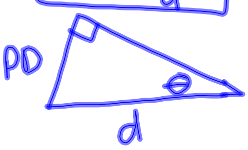
$PD = \overline{S_1P} - \overline{S_2P}$

$AP = S_2P$

$\therefore PD = S_1A$

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

$\sin\theta = \frac{PD}{d}$



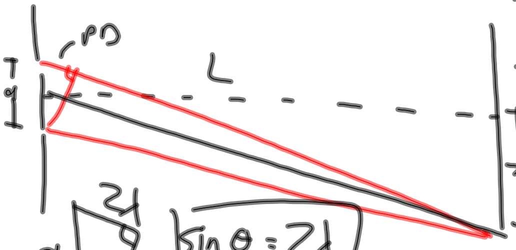
For small θ
$\sin\theta = \tan\theta$

$\frac{PD}{d} = \frac{x}{L}$

For destructive interference (dark spots) $PD = \frac{1}{2}\lambda, \frac{3}{2}\lambda, \frac{5}{2}\lambda \ldots$
$= (n - \frac{1}{2})\lambda$ or $\frac{2n-1}{2}\lambda$

For constructive (bright spot) $PD = n\lambda$

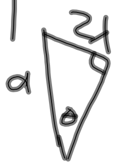
Example: A screen is 1.2 m away from two slits 0.03 mm apart. The second order bright "fringe" is 4.5 cm from the centre of the screen. Determine λ.



$L = 1.2$ m

$x_2 = 4.5$ cm $= 0.045$ m

$d = 0.03$ mm $= 3\times10^{-5}$ m



$$\sin\theta = \frac{2\lambda}{d}$$

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

$$\tan\theta = \frac{0.045}{1.2}$$

$$\theta = 2.15°$$

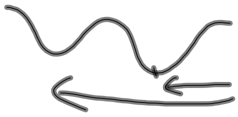
$$\sin 2.15 = \frac{2\lambda}{3\times10^{-5}}$$

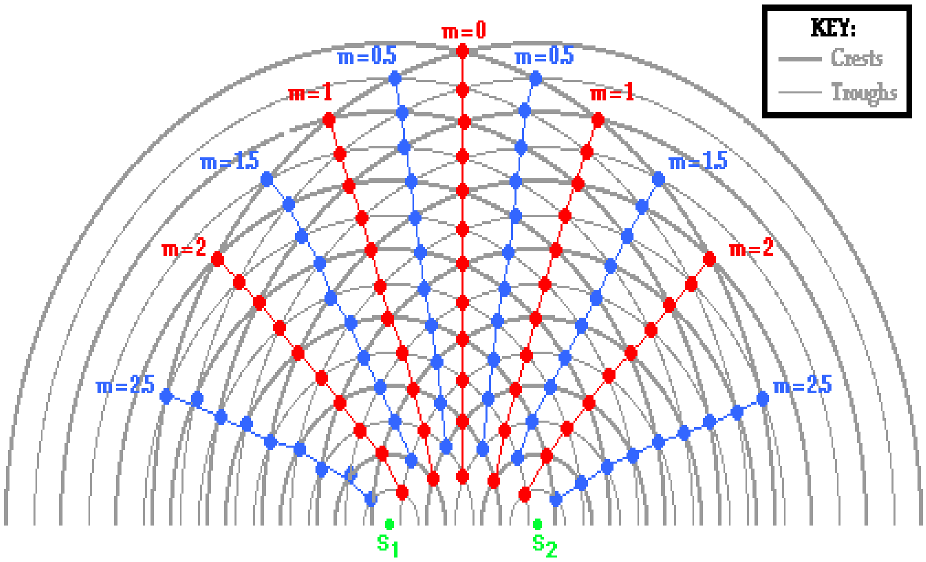
$\lambda = 5.62\times10^{-7}$ m or 562 nm

$$\frac{PD}{d} = \frac{x}{L}$$

$$2\lambda = \frac{(0.045)(3\times10^{-5})}{1.2}$$

$$\lambda = 562 \text{ nm}$$

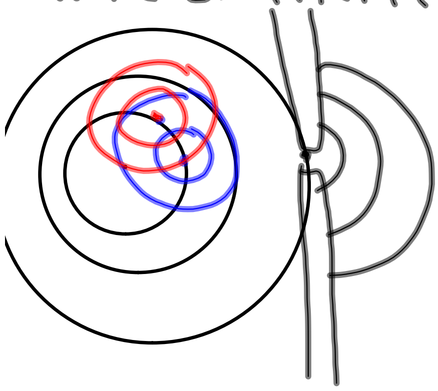


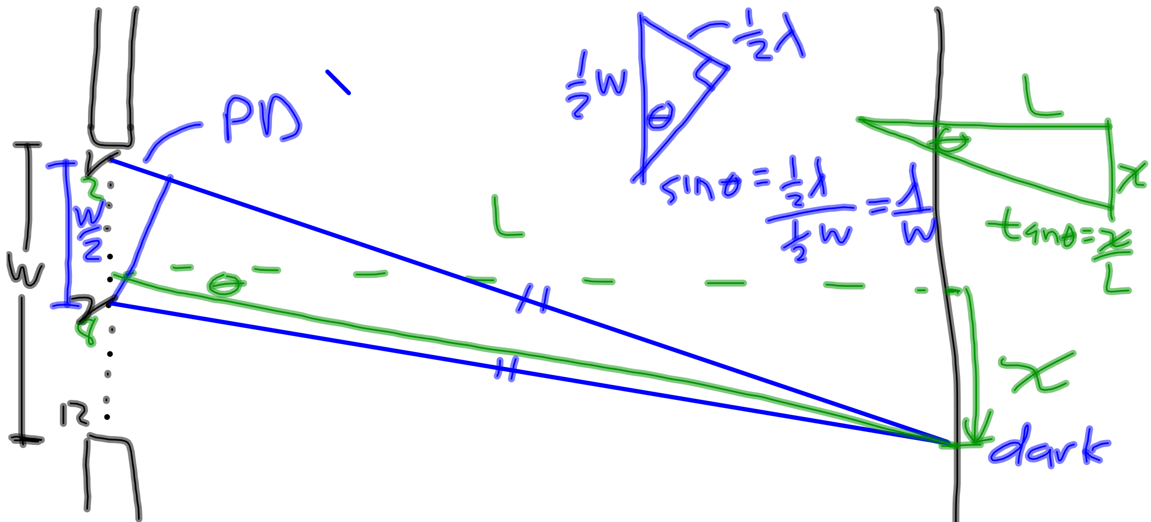


Single Slit Diffraction

Huygen's Principle:

Each point on a wave front is itself a source of a new wave. (The interference pattern between all these waves results in the total wave or interference that is visible)

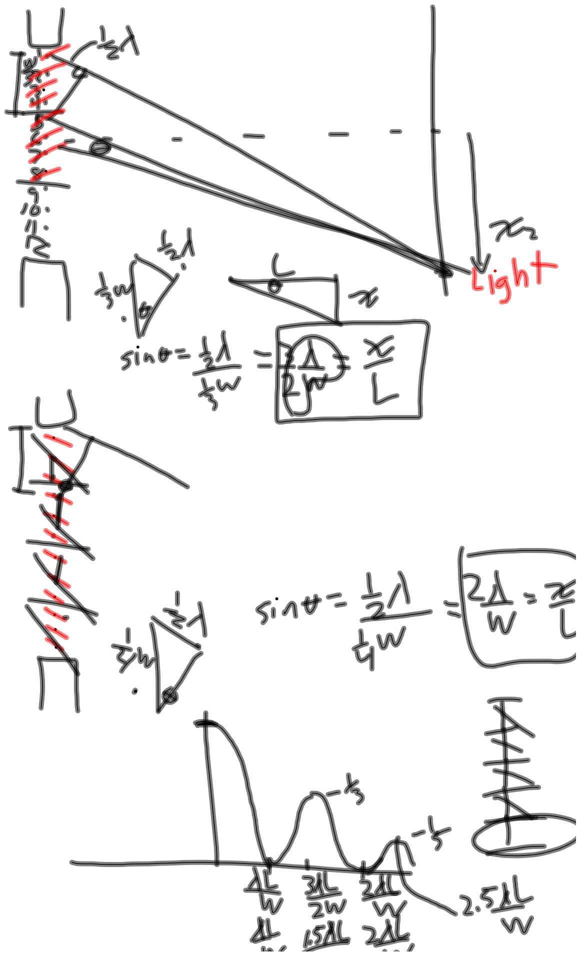




Consider this single slit as consisting of 12 individual sources of light coming from the original front.

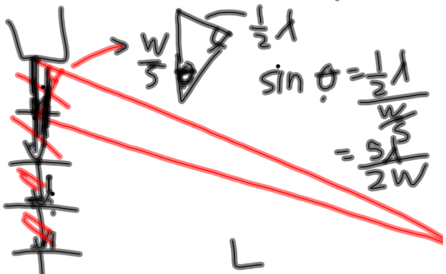
For small θ

$$\frac{\lambda}{w} = \frac{x}{L}$$



A screen is 1.2 m away from a single slit that is 0.03 mm wide. The 2nd order bright fringe is 0.045 m from the screen's centre. Determine λ.

$L = 1.2$ m
$w = 3\times10^{-5}$ m
$x_2 = 0.045$ m
$\lambda = ?$



$\sin\theta = \frac{\frac{1}{2}\lambda}{\frac{w}{5}} = \frac{5\lambda}{2w}$

since θ is small

$\tan\theta = \sin\theta$

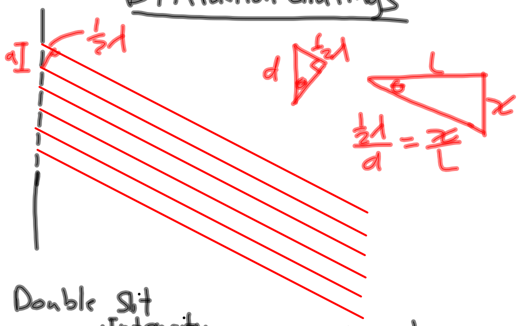
$\tan\theta = \frac{x}{L}$

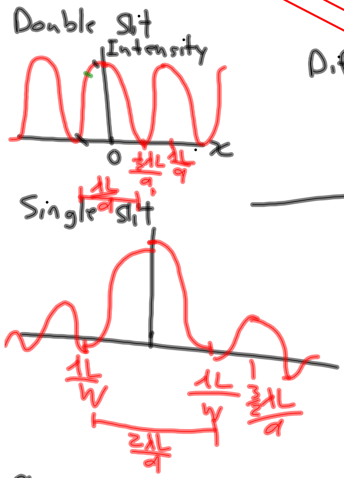
$\frac{x}{L} = \frac{5\lambda}{2w}$

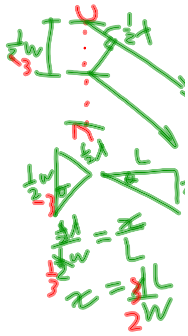
$\frac{2wx}{5L} = \lambda$ $\lambda = 450$ nm

$\frac{\lambda D}{d} = \frac{x}{L}$

Diffraction Gratings

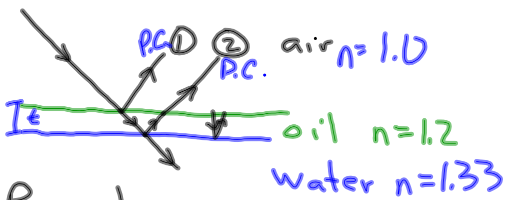






9.1 Review
9.3, 9.5 double slit
9.6
10.2 single slit
10.3 diff. gratings

Thin Film Interference



Remember: a phase change (P.C.) occurs when a light ray reflects off a surface with a higher index of refraction.

In the example above, what thickness of oil will result in 560 nm light (in air) being reflected brightly?

P.C. cancel — constructive interference

$\therefore$ P.D. $= n\lambda$ → for simplest (thinnest) $n = 1$

P.D. $= \lambda_{oil}$

also P.D. $= 2t$

$\therefore t = \frac{\lambda_{oil}}{2}$