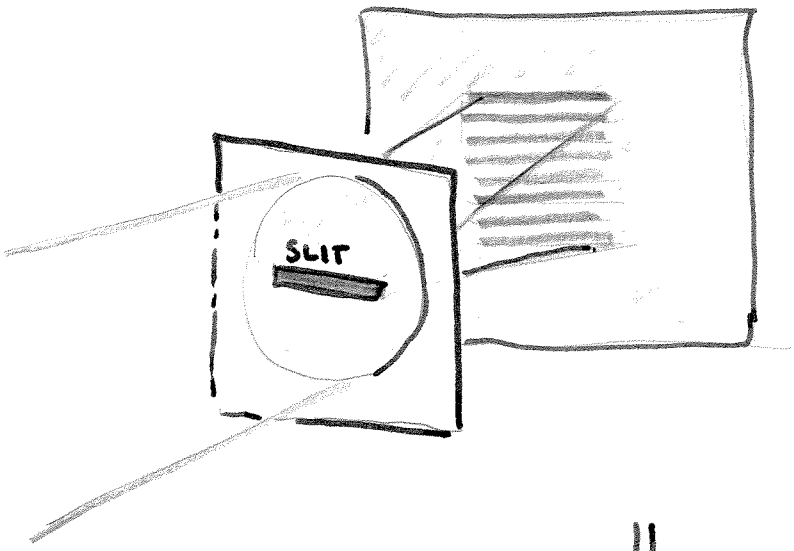
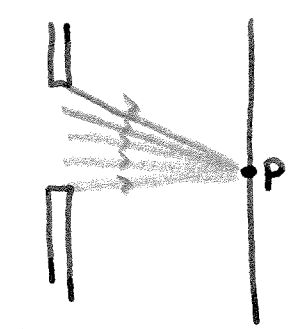
L5 DIFFRACTION

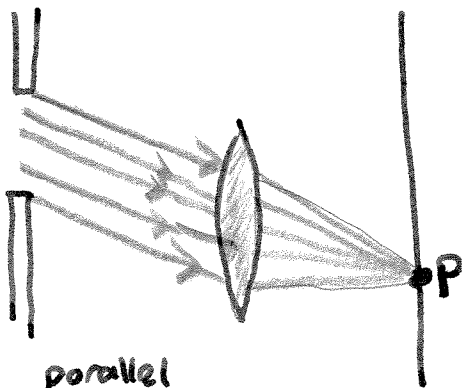
When any wave – sound, light, even matter waves, passes through an aperture of size comparable with its wavelength, the wavelets from the aperture interfere with one another to produce bright & dark fringes – this is called "diffraction".



diffraction pattern

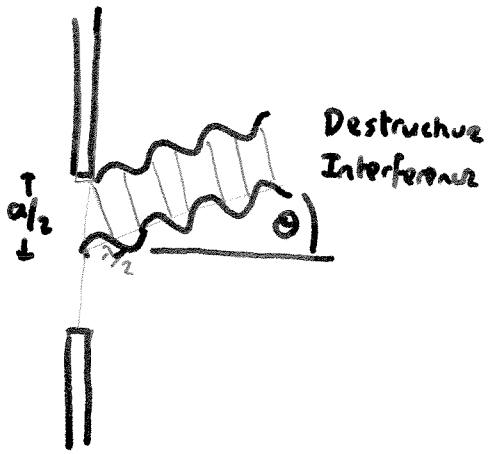


"Fresnel"



parallel beams

36.2 SINGLE SLIT DIFFRACTION



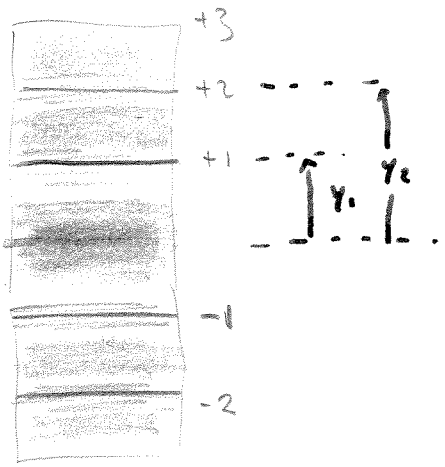
$$\frac{a}{2}\sin\theta = \pm\frac{\lambda}{2} \Rightarrow \sin\theta = \pm\frac{\lambda}{a}$$

More generally $\frac{a}{2m}\sin\theta = \pm\frac{\lambda}{2} \Rightarrow$ $\boxed{\sin\theta = \pm\frac{m\lambda}{a}}$ $m = \pm1, \pm2, \ldots$

DARK FRINGE.

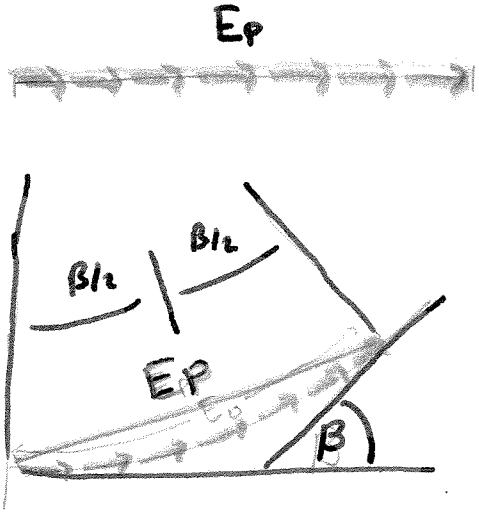
Small angle $\boxed{\theta = \frac{m\lambda}{a}}$

$m = 1, 2, 3\ldots$
(not zero!)



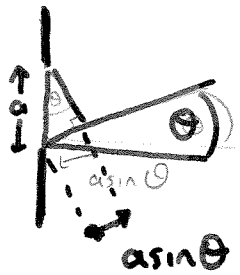
$$y_m = x\left(\frac{m\lambda}{a}\right)$$

36.3 Intensity in Single Slit



$E_p = E_0$

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

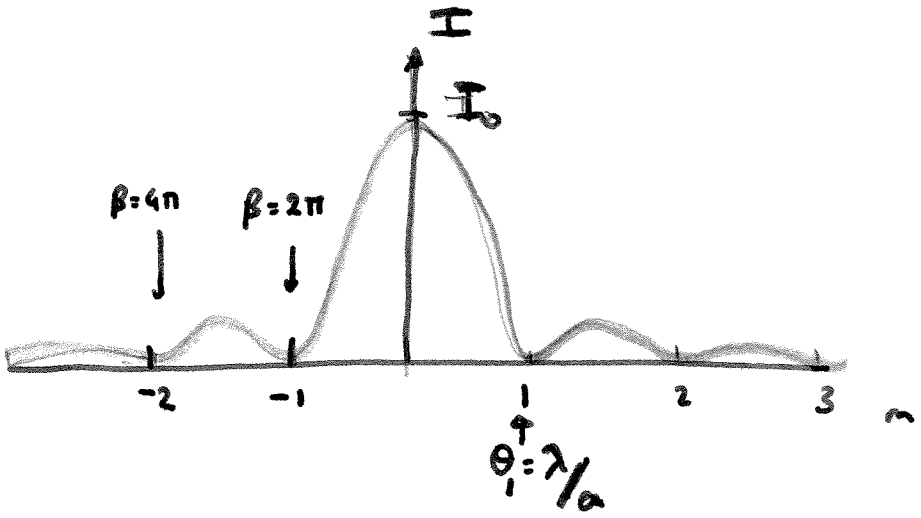


$$R\beta = E_0$$

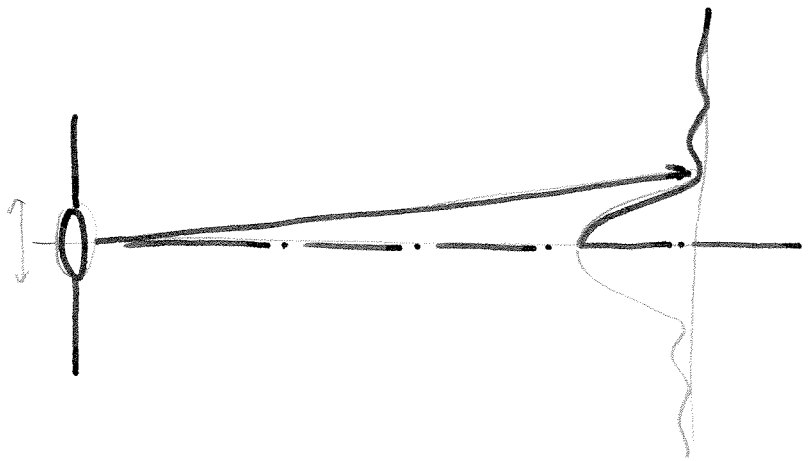
$$2R\sin\beta/2 = E_p = E_0\left(\frac{\sin\beta/2}{\beta/2}\right)$$

$$\boxed{I = I_0\left[\frac{\sin(\beta/2)}{\beta/2}\right]^2}$$

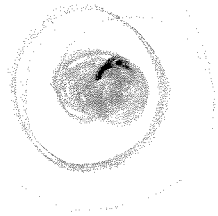
Angular width $\sim 2\frac{\lambda}{a}$



36.7 CIRCULAR APERTURES + RESOLVING POWER



$$\sin\theta_1 = 1.22\left(\frac{\lambda}{d}\right)$$



$$\Delta\theta \lesssim 1.22\,\frac{\lambda}{d}$$

TWO OBJECTS AT LESS THAN THIS ANGULAR SEPARATION CAN NOT BE RESOLVED

e.g Lens $d = 25\,mm$, object at $9\,m$.

What is the smallest object that can be resolved? $\lambda = 500\,nm$

$$\theta_m = 1.22\,\frac{(500)\times10^{-9}\,m}{25\times10^{-3}\,m} = 2.4\times10^{-5}\,rad$$

$$x = 9\,m \times 2.4\times10^{-5} = 2.2\times10^{-4}\,m = \underline{0.22\,mm}$$