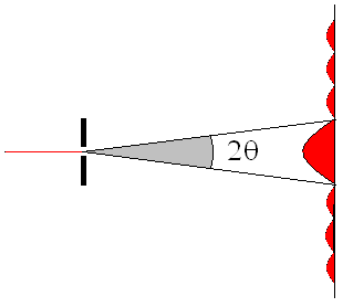
Physics II

Single Slit

Single slit: Dark fringes located at $\theta = \sin^{-1}\left(\frac{n\lambda}{width}\right)$, with n=integer, but not zero.

Problem 1.- In an experiment you shine red light of wavelength 633nm on a slit, generating a central diffraction peak of 2θ = 4.2º How wide is the slit?



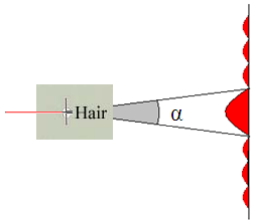
Solution: The first dark fringe in the diffraction pattern happens when $\lambda = D\sin\theta$, so:

$$D = \frac{\lambda}{\sin\theta} = \frac{633nm}{\sin 2.1^{\circ}} = \mathbf{17\ \mu m}$$

Problem 1a.- A thin rectangular aperture is illuminated with a He-Ne laser (like you did in the lab) and it is observed that the first dark fringe happens at an angle of 3.55º from the center. Calculate the width of the aperture knowing that the wavelength of the laser is 632.8 nm.

Solution: Since: $\lambda = W\sin\theta \rightarrow W = \frac{\lambda}{\sin\theta} = \frac{632.8\times10^{-9}m}{\sin 3.55^{\circ}} = \mathbf{10.2\ \mu m}$

Problem 1b.- In an experiment you shine red light of wavelength 633nm on a single hair. The diffraction pattern looks as if it were a single slit (Babinet's theorem) and the central peak subtends a total angle of α = 8.4º How thick is the hair?



Problem 2.- A diffraction grating is used to diffract the light emitted by a flame spectrometer and detect sodium (wavelength of 589nm). At what angle should we set the detector if the line density of the grating is 20,000 lines per inch? [1 inch = 0.0254 m].

Solution: The equation for the first diffraction fringe is $\lambda = d\sin\theta$, so the angle is $\theta = \sin^{-1}\left(\frac{\lambda}{d}\right)$

The distance between lines is: $d = \frac{0.0254m}{20{,}000} = 1.27\times10^{-6}m$

So the angle is: $\theta = \sin^{-1}\left(\frac{589\times10^{-9}}{1.27\times10^{-6}}\right) = \mathbf{27.6^{o}}$

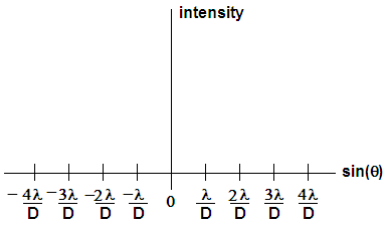
Problem 3.- What happens to the interference pattern of a double slit when you reduce the distance between the slits?

Solution: The angle between the central maximum and the first bright fringe in a double slit interference pattern is given by:

$$\sin(\theta) = \frac{\lambda}{d}$$

So, if the distance *d* is reduced, the angle will be larger, spreading the pattern.

Problem 4.- Sketch the intensity of light after passing through a single slit. D is the width of the slit, the light wavelength is λ and sin(θ) is the sine of the deflected angle.



Solution: