Physics 223
Experiment 7: Diffraction from a Single Slit

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When light passes through a small aperture or near sharp edges, it "spreads" in a phenomenon called diffraction. This is due to interference from Huygens wavelets originating from different parts of the aperture.

Suppose we have a beam of monochromatic light incident on a single small slit of width a. If the slit dimension is on the order of the wavelength of the light, it will be diffracted and form a pattern of maxima and minima. In order to see how this can happen, imagine that the slit is divided into two portions as shown in Figure 1, an upper half and a lower half. For every point **A** in the top half, there is a corresponding point **B** in the lower half of the slit. Consider the light from each of these two corresponding points impinging on the screen at point **P**. If the distance to the screen L is sufficiently large ($L \gg a$), the light traveling along **BP** will travel further than that along **AP** by an amount

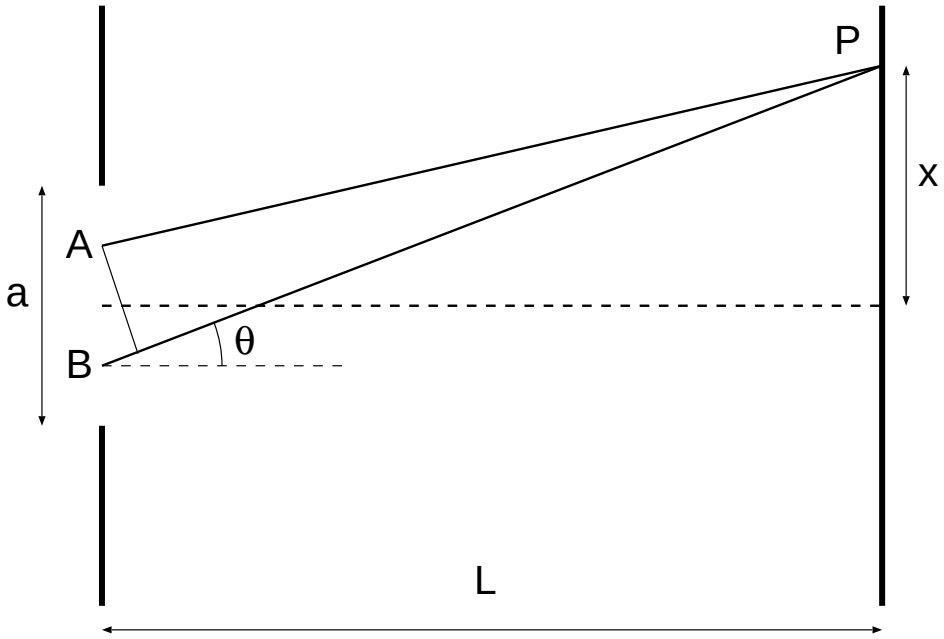
$$\Delta x = \frac{a}{2}\sin\theta. \tag{1}$$

When this path length difference is exactly $\lambda/2$ then waves from each point in the upper half of the slit will destructively interfere at the screen with their corresponding wave from the lower half of the slit, resulting in a minimum in intensity. This will be the first minimum in the diffraction pattern (with the central maximum being at $\theta = 0$). The second minimum can be found in a similar way by dividing the slit into 4 equal portions and the third minimum by dividing the slit into 6 pieces. In general, we find that

$$\frac{a}{2n}\sin\theta = \frac{\lambda}{2} \longrightarrow a\sin\theta = n\lambda \qquad n = 1, 2, 3\ldots \tag{2}$$

Between each pair of minima there will be a maximum, however unlike simple double slit interference, these maxima are not equidistant from the minima. The intensity of a diffraction pattern can be derived by using the phasor construction and is given by:

$$I(\theta) = \left| \frac{\sin(\pi a \sin\theta/\lambda)}{\pi a \sin\theta \quad /} \right. \quad / \qquad\qquad / \quad . \qquad .$$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